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DEVELOPMENT OF AN INTEGRATED GAME BASED MANAGEMENT SYSTEM FOR THE TRANSFORMATION OF CASSAVA INTO ITS END-PRODUCTS

End of cycle dissertation presented by:

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Dedication

This dissertation is dedicated to my loving mother Ngala Mufup Dorothy.

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Abstract

Attention and thought are indispensible ingredients to learning. Unfortunately, they are very scarce in today's learners. Also, it is virtually impossible to become proficient in a task without extended practice. Sadly, students resist practice and find it boring. Even when they find it interesting, practicing certain lessons in school is very resource intensive; that is the case for the lesson on transforming cassava into its end-products in form five. The above issues pushed us to ask the following 3 questions: how can one increase student attention and retention? How can one make learning happen faster? How can one give students the opportunity to practice on the transformation of cassava into its end-products while making it fun and cheap? To address these issues, we decided to develop a digital game based management system that enhances the lesson on the transformation of cassava into its end-products.

With the help of the method GADDES which resulted from integrating ADDIE, SCRUM and learning strategies (gamification and micro-learning), we examined difficulties in understanding and teaching of this lesson, applied best practices for developing quality instructional products and software to produce an educational game called "Cassava King".

After applying the first three phases of the model GADDES; the educational game "Cassava King" took its first breath. Using a control and an experimental group, we assessed the control group after a traditional lesson and the experimental after a lesson with "Cassava King". The experimental group performed better than the control group by up to 20%. Also, we noticed that the students in the experimental group that failed the test retained the tools and transformation process. We also looked at some criteria known by educators to improve learning and noticed that "Cassava King" not only meets these criteria, but can also accelerate learning. Moreover, we noticed from our usability test that cassava king has at least an average mark in all the usability criteria defined by Bastien & Scapin.

The educational game "Cassava King" will allow teachers to complement their lesson; since the practical part of it is almost unfeasible because it requires equipment and resources (which are expensive). It will not only help students to learn by interacting and playing which makes learning interesting, but will also make the lessons more concrete than a traditional lesson.

Key words: ADDIE, gamification, micro-learning, educational game, SCRUM

Résumé

L'attention et la réflexion sont indispensables à l'apprentissage. Malheureusement, ils sont très rares chez les apprenants d'aujourd'hui. En outre, il est pratiquement impossible de maîtriser une tâche sans une pratique prolongée. Hélas, les étudiants résistent à la pratique et la trouvent ennuyeuse. Même lorsqu'ils le trouvent intéressant, pratiquer certaines leçons à l'école nécessite beaucoup de ressources; c'est le cas de la leçon sur la transformation du manioc en ses dérivés en classe 2nde. Les problèmes ci-dessus nous ont poussés à poser 3 questions: comment augmenter l'attention et la rétention des apprenants? Comment peut-on accélérer l'apprentissage? Comment permettre aux élèves de s'exercer à transformer le manioc en ses dérivés tout en le rendant amusant et économique? Pour résoudre ces problèmes, nous avons décidé de développer un système de gestion basé sur les jeux qui complément la leçon sur la transformation du manioc.

À l'aide de la méthode GADDES issue de l'intégration d'ADDIE, SCRUM et des stratégies d'apprentissage (« gamification » et micro-apprentissage), nous avons examiné les difficultés de compréhension et d'enseignement de cette leçon, appliqué les meilleures pratiques pour développer un dispositif pédagogique et avons produit le jeu éducatif appelé « Cassava King ».

Après avoir appliqué les trois premières phases du modèle GADDES; le jeu éducatif « Cassava King » a vu le jour. À l'aide d'un groupe témoin et d'un groupe expérimental, nous avons évalué le groupe témoin après une leçon traditionnelle et l'expérimental après une leçon avec «Cassava King». Le groupe expérimental a obtenu de meilleurs résultats que le groupe témoin avec une différence de 20%. Nous avons également remarqué que tous les élèves du groupe expérimental ont retenu les outils et le processus de transformation. Nous avons également examiné certains critères connus des éducateurs pour améliorer l'apprentissage et avons remarqué que « Cassava King » répond non seulement à ces critères, mais peut également accélérer l'apprentissage. De plus, nous avons remarqué dans notre test d'utilisabilité que le jeu a au moins la moyenne dans tous les critères d'utilisabilité définis par Bastien & Scapin.

En somme, le jeu permettra aux enseignants d'appuyer leur leçon étant donné que la pratique de celle-ci est quasi inexistante car nécessite les ressources couteuses, et aux élèves d'apprendre en jouant ce qui rend l'apprentissage intéressant et plus concret que le cours théorique.

Mots-clés: ADDIE, « gamification », micro-apprentissage, jeu éducatif, SCRUM

List of Acronyms

MINISEC	**Mini**stry of **S**econdary **E**ducation **C**ameroon
GBPHS	**G**overnment **B**ilingual **P**ractical **H**igh **S**chool
GBL	**G**ame **B**ased **L**earning
DGBL	**D**igital **G**ame **B**ased **L**earning
ICT	**I**nformation and **C**ommunication **T**echnology
VLE	**V**irtual **L**earning **E**nvironments
CMS	**C**ontent **M**anagement **S**ystems
LMS	**L**earning **M**anagement **System**
ID	**I**nstructional **D**esign
IEEE	**I**nstitute of **E**lectrical and **E**lectronic **E**ngineers
FAQ	**F**requently **A**sked **Q**uestions
ADDIE	**A**nalyze, **D**esign, **D**evelop, **I**mplement, and **E**valuate.
SAM	**S**uccessive **A**pproximation **M**ethod
SMART	**S**pecific, **M**easurable, **A**ction oriented, **R**easonable, **T**imely
TBT	**T**echnology **B**ased **T**raining
SME	**S**ubject **M**atter **E**xpert
e-learning	**E**lectronic **learning**
XP	E**x**treme **P**rogramming
HIHS	**H**oly **I**nfant **H**igh **S**chool
SME	**S**ubject **M**atter **E**xpert
KSA	**K**nowledge, **S**kills, **A**bilities
MoSCoW	“Must have,” “Should have,” “Could have,” and “Won’t have”
HTTC	**H**igher **T**eachers **T**raining **C**ollege
GADDES	**G**amified **A**nalysis **D**esign **D**evelopment and **E**valuation with **S**crum

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Chapter 1: **Introduction**

1.1. Context

The advent of information and communication technology has transformed the world into a global village and has impacted most sectors of life; education inclusive. The integration of technology into the teaching-learning process is considered as an important process that would enhance comprehension and creativity in the learner for an optimal learning outcome (MINISEC 2014, p15).

Knowing the importance of integrating technology in the teaching-learning process, the Cameroon government in 2007, created the Department of Computer Science and educational technologies in HTTC Yaounde. This new department was not only created to train teachers of computer science but also to train teachers that will use information and communication technology to produce educational resources that will enhance the teaching-learning process in other subjects like Geography, Biology, French, English, etc.

That is why, ever since the creation of the Department of Computer Science and educational technologies in HTTC Yaounde, the level 5 students of this department produce pedagogic resources that enhance learning as their end of year research work in subjects like Geography, English, French, just to cite a few.

In 2017, the attention was focused on building educational resources for first cycle biology, which according to MINISEC in "the teacher's guide for science and technology syllabus" (2014, p4) state that the general aim of the first cycle biology program is to: "inculcate the learner with responsible behavior, knowledge and competencies necessary for meeting with the challenges of the rapidly changing technological world".

As level 5 students in the computer science department of HTTC Yaounde, it is our turn to craft pedagogical resources for our final year project. Like in 2017, the focus for this year is on first cycle biology. So, as our end of year research work, we are expected to develop an educational resource (tutorial) that enhances the concept of biotechnology and transformation of food; more precisely the transformation of cassava into its end-products like "garri", "water fufu", "bobolo", etc. We will have to produce this tool with respect to the needs of the students, teachers, schools, and MINESEC goals.

1.2. Statement of Problem

Students seem to be more interested in taking part in the process of transforming cassava into its end-products than just hearing about it. That is one of the findings we had during our survey at

GBPHS and HIHS Yaounde. Like students, most teachers disclosed that the ideal lesson would have been based not only on hearing or seeing how to do it, but practically experimenting it. Most of the teachers declared such a solution to be impractical not only because of the risk that some of the students may get hurt while using the different elements needed for this transformation, but also because of how demanding it will be in resources, time, and energy.

The survey also revealed that 61% of the students cannot focus for up to five minutes during traditional lessons; which ties with the opinion of most teachers that were interviewed. The students also disclosed that they find the traditional lessons boring, and thus are not very engaged during traditional classes. Most teachers also complained on the low retention capacity and very little or no engagement of the students during the teaching-learning process.

1.3. Research questions

In the course of this work, specific research questions to be answered were:

- How can one give students the opportunity to practice on the transformation of cassava into its end-products while mitigating the above exposed pitfalls?
- How can one augment attention and retention of students?
- How can one make learning happen faster?

1.4. Aim and objectives of the research

The aim of this research was to develop an integrated game based management system for the transformation of cassava into its end-products. This game based management system is called: "cassava king". The specific objectives of this research were the following:

- Build an information system that provides content and activities that can help enhance skills needed to transform cassava into specific end-products.
- Integrate into the learning process modern concepts that facilitate retention, engagement, attention, and manipulation like gamification, and micro learning into the game based management system.
- Design and implement scenes of the game so that the learner can play while learning.
- Provide possibility for teachers to customize certain aspects of the information system.

1.5. Scientific contribution

This game based management system is the first in the Cameroonian context that deals with the transformation of cassava into its end-products. It will not only provide a possibility for students to practice and retain how to transform cassava into its end-products, but it can also be extended to teach other concepts like resource management, entrepreneurship, responsible health behaviors during manufacturing, and more. Like other tools already developed in the Cameroonian context, this tool will provide the:

- Possibility to be used online and offline

- Possibility to be used in school and at home
- Possibility for students to get use to technological pedagogic resources
- Possibility for teachers to use blended approaches of teaching that is more effective than traditional teaching.
- Possibility for teachers to modify the content and evaluation questions of the system.

1.6. Basic concepts

Before exposing our plan and entering into other parts of this dissertation, it was appropriate to define some terms that can help understand our research. Consequently, we will throw more light on the following concepts:

- **End-products of cassava**: they are other edible and non-edible products derived from cassava using biotechnology. Examples of end-products of cassava are: "garri", "water fufu", starch, "bobolo", etc.
- **Game based Learning (GBL)**: is described as a branch of serious games that deals with applications that have defined learning outcomes. GBL has the potential of improving training activities and initiatives by virtue of its engagement, motivation, role playing, and repeatability (T Suzi & Al, 2007).
- **Digital Game Based Learning (DGBL)**: is a pedagogical method of teaching concepts through play in digital simulations (Pappas & Al 2016, p24.).
- **Game**: is a system where players engage in an abstract challenge defined by rules, interactivity, and feedback that results in a quantifiable outcome or objective, often eliciting an emotional reaction (Karl Kapp 2014).
- **Gamification**: is the process of applying game elements, game mechanics and game thinking to nongame situations (Karl Kapp 2014)
- **Game based management system**: it is an information system that stores data on game resources used in DGBL.
- **Instructional design**: is the systematic development of instructional specifications using learning instructional theory to ensure the quality of instruction. It is the entire process of analysis of learning needs and goals and the development of a delivery system to meet those needs. It includes the development of instructional materials and activities, and try out and evaluation of all instruction and learner activities (University of Michigan).
- **Instructional design models:** they give frameworks for outlining training programs. Each model breaks down the training development into smaller segments, but all models have some sort of analysis, development and evaluation. They may have different methods for approaching those stages or breaking them down into more manageable pieces (Shea Hanson 2014).
- **Learning objects:** they are digital resource designed for educational purposes to assist learning (D. Wiley, 2000).

- **E-learning**: refers to the acquisition of knowledge and skill using electronic technologies such as computer- and Internet-based courseware and local and wide area networks (Microsoft® Encarta® 2009).
- **Software development**: it is a systematic approach of analyzing, designing, implementing, and testing computer programs to optimize their production and support.

1.7. Plan

So far, this chapter has set the scene for this research by uncovering its context, problem, aim, and objectives. We also thought it necessary to define some key words necessary for the comprehension of our theme. The rest of this dissertation will be structured as follows.

Chapter 2 will focus on existing relevant work necessary in answering the research questions and achieving the aim of this research. We will thus focus on domains of knowledge such as: Instructional design models like ADDIE and SAM, instructional strategies like Gamification and micro-learning and agile software development methods like SCRUM and XP.

Chapter 3 will in one part, expose the underpinning ideas and assumptions on which the models and strategies chosen were made and the methodology used. In another part, it will then highlight how we applied the methodology, ideas, and assumptions to achieve the aim of this research work.

Chapter 4 will highlight the findings and results achieved after applying the methodology of chapter 3.

Chapter 5 will focus on how this project can influence the Cameroonian educational system, answers to the research questions and recommendations for future work.

Chapter 2: Literature Review

2.1. Problems of Education

Louisa Kendal in her article entitled: "three biggest challenges facing education in 2018", claims that, the changing job market is one of the main problems faced by education in 2018. This statement corroborates with that made by MINISEC (2014, p3) during their redefinition of syllables for a 21st century Cameroon. This idea of a changing job market was already stated by the organization called Partnership for 21st century skills in their article "21st century skills, education and competitiveness" when they attested that: "the industrial economy has been replaced with a service economy driven by information, knowledge, and innovation (2008, p2). Partnership for 21st century skills (2008, p10) proposes that a possible solution to the changing job market problem is to make sure educational programs promote the following skills: critical thinking, usage of knowledge from different domains to solve problems, creativity and entrepreneurial thinking, team work, and making innovative use of knowledge. This same solution is advocated by MINISEC (2014, p7).

The inefficiency of traditional teaching is advocated by Mohammed G.S & Al (2018, p32). He states that traditional learning is unable to lead students towards innovation and creativity because traditional learning cannot motivate students to learn new things. Hug & Friesen (2007) follows the same trend by stating that: the knowledge which students are gaining from traditional teaching method is easily forgotten. It has also been reported that the traditional learning process can reduce student's attention. Integrating technology in education has proven to be better at motivating and captivating learners than traditional methods. MINESEC (2014, p15) supports this statement by advocating that: "the integration of technology into the teaching-learning process is considered as an important process that would enhance comprehension and creativity in the learner for an optimal learning outcome".

In the Cameroonian context, apart from the problems provided above, other specific problems like large class sizes, poor infrastructure, insufficient human resources, unmotivated teachers and little or no professional conscience, and political problems are additional problems faced by education. This idea of political problems in the world is supported by Louisa Kendal (2018) when she states that: "we are in an increasing unsteady political world". She claims that one of the main ways to prevent this political unsteadiness to lead to the crumbling of economies and even the world is through education. Louisa Kendal (2018) advocates that integrating social and emotional intelligence in educational programs and being able to: emotionally connect with others, empathetically relate to difficult situations, and having the nuance to navigate complex social issues is paramount to maintaining peace and stability in the future. The redefinition of secondary school programs by MINISEC (2014) integrates social and emotional intelligence in the school program.

Problems of education related to the study of biology was mentioned in Fozewong (2017) where he cites the work of Jean-Pierre Gallerand who developed an educational software that has helped to improve the learning of biology. As a biology teacher, he realized that children who encountered many difficulties in understanding biology lessons did not have sufficient means to carry out certain experiments. The virtual means could thus be a practical and less costly solution. Muchwe K.J (2014) on his part realized that despite educationists' efforts; performance in science subjects is still very poor among secondary school students. His study investigated the factors that contribute to poor performance in science subjects among students in secondary schools. The main findings of this study showed that among many other reasons the common reasons that contribute to poor performance are poor methodology in science education, negative attitude towards science subjects among students and lack of resources such as text books and well equipped laboratories.

Educational technologies can thus be means to provide virtual environments for experiments. Apart from providing an environment to simulate certain learning activities, educational technology promises to revolutionize the education system in every way, from streamlining homework and marking, to giving students with special needs the support they require (Louisa Kendal 2018).

2.2. Educational technologies

The constant evolution of technologies continues to offer new and appealing opportunities for educators leading to the concept of educational technology. Educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources (Richeley & Al, 2008).

Developments in recent years have seen web-based VLE/CMS/LMS rapidly becoming an integral part of teaching and learning process. This emergence progresses incessantly as educators attempt to adopt and adapt web 2.0 technologies in the provision of more interactive teaching materials and learning environments (Ilana de Almeida & Beatriz de Almeida, 2013, p38). LMSs are software used to establish the teacher – student communication and work as an interface to assist the E-learning process. LMS support multiple media and resources in order to provide the educator a possibility to create and deliver content, monitor student participation, assess student performance, and provide students the ability to use interactive features such as forums and chats. Examples of LMS are Moodle, Blackboard and WebCT.

Ilana de Almeida & Beatriz de Almeida (2013, p38) in "Games and Learning Management Systems: A Discussion about Motivational Design and Emotional Engagement" advocates that one of the main complaints from students and teachers on the use of technologies like LMS is that their experience is no different from that of traditional classrooms due to low interactivity of student and low quality of the proposed material. In order to blend the informal learning of the learner and to make the educational process more playful emerged at the end of the twentieth

century, the concept of learning objects which are digital resources designed for educational purposes to assist learning. With this, investigations on how play could influence learning were made and other types of LMS (Academy LMS, Axonify, Accord LMS, ExpertusONE, TalentLMS) that integrated elements of game mechanics where developed. Platforms for learning such as codeAcademy also included elements of play into their learning experience. Ilana de Almeida & Beatriz de Almeida (2013) argues that if integrated properly, games may enrich an LMS and make the teaching and learning process more interesting and effective.

2.3. Games in education

In the yesteryears, games were only used for entertainment. Their use in the classroom was not even considered. Today, educators are interested in the effective and motivational aspects provided by digital games in order to engage students in the learning process. In contrast to most games built for entertainment, educational games are designed to help learners achieve specific learning objectives while at the same time providing a motivational environment (Ruth Colvin Clark and Richard E. Mayer, 2011).

Ilana de Almeida & Beatriz de Almeida (2013, p40) advocates that the use of games as a teaching and learning strategy in the classroom is a great resource. It creates situations that allow students to develop problem-solving methods, stimulates their creativity in a challenging environment while motivating them.

According to Smole et Al (2007), working with games is a resource that benefits the development of learning different reasoning processes and interaction among students; since during a game, the player can follow the work of others, defend their points of view and learn to be critical and confident.

Peña-Miguel Noemí & Sedano Hoyuelos Máximo (2014, p237) conclude in their article that serious games have great potential for training because they have a highly positive effect on the learning process of users. This is due to the fact that they attract users in a simple, dynamic way and turn them into the protagonists of their own learning processes.

Margaret A. Honey and Margaret L. Hilton (2011, p15) advocate the power of games in facilitating the learning of sciences by citing a web based survey conducted by Goldman, Koepfler, and Yocco (2009) on the game "WolfQuest": "most respondents indicated that they had sought out more information about wolves and their environments, suggesting that the game motivates interest in science learning. Analysis of players' self-reported knowledge of wolves, their behaviors, and habitats before and after playing "WolfQuest" suggests that the game has a positive impact on conceptual understanding of wolves".

McClarty et Al (2012) states that: an attractive element of the gaming experience as a learning tool is that it provides opportunities for continued practice because negative consequences are not typically associated with failure. Rather, failure serves as an integral part of the learning

experience. This encourages either players to improve through repeated practice by advancing within a game or replaying parts of a game.

Games in education do not only have a bright side. Ethan Edwards in his article "Get in the Game: Three Essential Design Elements for Creating Engaging E-Learning Games" (2017, p2) holds that educational games fail to succeed in creating irresistible experiences in the way that recreational games do. Evidence is mixed regarding the degree to which games make a difference, and some of the widely-accepted design elements (points, avatars, etc.) don't necessarily correlate with success or learner enjoyment; perhaps because it is so difficult to attach specific outcomes to gaming approaches. Ilana de Almeida & Beatriz de Almeida (2013, p44) comment that effective educational games must educate and at the same time cause a sense of satisfaction and pleasure. Ruth Colvin Clark and Richard E. Mayer, (2011, p378) address the fact that, games teach, but the lesson learned is not always the intended one. They argue this point of view by citing the test conducted by Reiber (2005). They conclude from Reiber's experiment with the statement: "In this experiment, we see that a gaming environment can be a lot of fun and at the same time depress learning. Why? The game goals generated behaviors that were antagonistic to the instructional goals".

How then do we make sure we get behavioral and psychological activities from the players? How do we blend fun with the learning objectives? Ruth Colvin Clark and Richard E. Mayer, (2011, p381) state 6 evidence based design principles to follow when designing serious games. They are:

- Principle 1: Match game types to learning goals
- Principle 2: Make learning essential to game progress
- Principle 3: Build in proven instructional strategies
- Principle 4: Build in guidance and structure
- Principle 5: Manage complexity
- Principle 6: Make relevance salient

Ethan Edwards (2017, p6) argues that fun is exceptionally hard to create out of thin air when attempting to design a successful learning game. Instead of "fun", a better goal in applying game design principles to e-learning may be to strive for "engagement." If designed to maximize engagement, a learning module will very often end up being fun, even if that wasn't the specific goal. He then proposes 3 key factors that enhance user engagement which are:

- Risk
- Meaningful actions
- Compelling frame (rules)

Margaret A. Honey and Margaret L. Hilton (2011, p45-52) propose a non-exhaustive list of game design elements that influence learning. These elements are:

- Focus on Clear Learning Goals
- Provide External Scaffolding
- Representation
- Narrative/fantasy
- Feedback
- User control
- Individual learner differences

Since the above principles and concepts are research and evidence based, integrating them correctly in the design of a game will lead to an efficient learning object in the form of a game. Ilana de Almeida & Beatriz de Almeida (2013, p38) state that learning objects are part of an area known as instructional design; which is the process to identify a learning problem, design, implement and evaluate a solution to this problem.

2.4. Instructional Design

To craft an instructional product or learning object is to pay suitable attention on 2 things: the conditions under which learning occurs, and the application of a systematic process. Instructional design refers to the process used to create an effective instructional product.

According to George M. Piskurich in "Rapid instructional design" (2006, p3), instructional design is a set of rules or procedures for creating training that does what it is supposed to do. Luca Botturi (2003) defines instructional design by citing Smith and Ragan as: "the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources and evaluation" (Ragan & Smith 1999, p.2). Luca Botturi also cites the definition of IEEE which is: "the process through which an educator determines the best teaching methods for specific learners in a specific context, attempting to obtain a specific goal" (IEEE 2001, p.1).

Our work on: developing an instructional product in the form of an integrated game based management system for the transformation of cassava into its end-products, sprouts from the seed of instructional design. Our work can thus be seen as the crafting of an instructional product or learning object which demands that we apply an instructional design model. The necessity of choosing an instructional design model is advocated by Zahira Merchant in her article "Instructional design FAQ for beginners" (2018) by stating: "A fundamental step in instructional product development is to select an Instructional Design model and strategy." An instructional model refers to a step-by-step process to produce instructional products (Zahira Merchant, 2018). Luca Botturi cites Gustafson and Branch's opinion on instructional model as follows:

"Instructional development models are almost as numerous as the practitioners of instructional development. The role of models in instructional development is to provide conceptual and communication tools that can be used to visualize, direct and manage processes for generating

episodes of guided learning" (Gustafson & Branch 1997, p.73). Gustafson and Branch also add that the application of a model "…Is not necessarily linear and may be quite dynamic, recursive and never ending."

The bottom line from these definitions of an instructional model stays that: they are a means used by instructional designers to craft an instructional product.

Literature talks about many instructional design models such as: ADDIE, SAM, Backward Design, Dick and Carey, Knirk and Gustafson, Rapid prototyping, Hannifan and Peck, etc. In the next section we will present the most popular traditional methodology (ADDIE) and the most popular agile methodology (SAM).

2.4.1. Instructional Model: ADDIE

ADDIE is an acronym where every letter corresponds to one of the model's main phases: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE methodology was developed in Florida State University's Center for Educational Technology back in the seventies. Initially, the model was meant to be used in the US armed forces, a fact to which it owes its streamlined processes and clear delineation of phases. Despite being nearly forty years old, the methodology has not fallen out of use (Michael Treser 2015).

The popularity of ADDIE is owed to the fact that: it is simple to use, flexible, and versatile. Also, It is easy to learn, and is cyclical; that is, it enables you to correct the errors made in previous iterations, thus improving the quality of the end product. Figure 1 shows how versatile and flexible the ADDIE model can be.

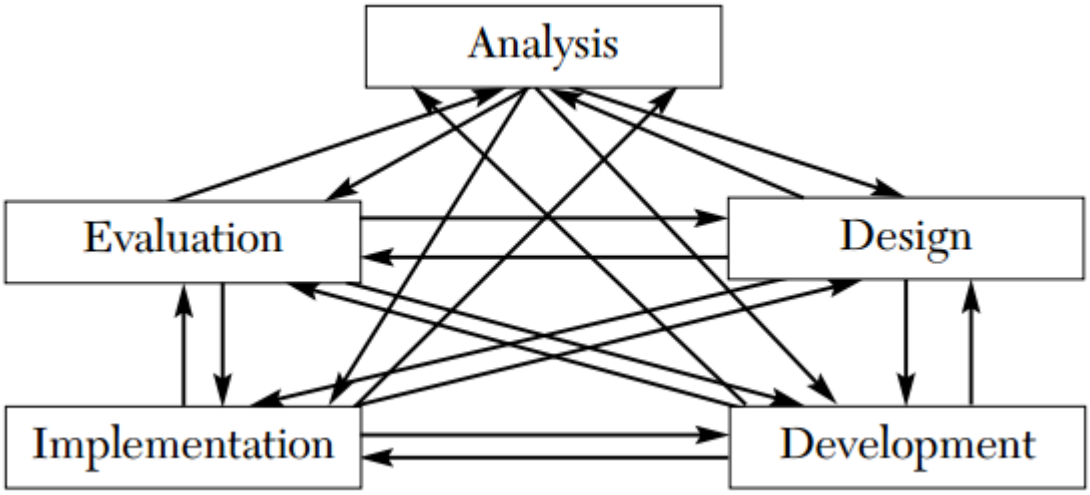

Figure 1: Instructional system design; spider web model of ADDIE

Cited in George M. Piskurich 2006, p5

A brief description of the 5 phases of instructional design is given below.

Analysis: the goal of the analysis phase is to gather information with the aim of knowing the following:

- Critical parts of the subject matter
- Characteristics of the target learners
- Delivery method that suits the content, organization, and learners.

Each aforementioned aim demands a specific type of analysis as shown in Figure 2 that follows.

Type	*Purpose*	*Sequence*	*Best Methods*	*Product*
Learning Analysis	To determine the critical learnings necessary to meet a training need.	Done in lieu of a job and task analysis.	Interviews with SMEs or focus groups	A prioritized list of critical learnings that must be mastered to meet the training need.
Audience Analysis	To determine the characteristics of the target learners that will be critical for program development.	Might be done any time during the design process, but always before developing program materials.	Questionnaires and interviews with learners and others who know the characteristics of the learners.	A list of general learner characteristics that the instructional designer needs to consider when creating course materials.
Delivery Analysis	To determine the best training delivery method for the course content, the organization, and the learners.	Might be done any time during the design process, but always before developing program materials.	This is done by the instructional designer, possibly with help from the training manager and other resources in theorganization such as IT.	A decision on the most effective and efficient delivery method that takes into account the requirements of the content, the capabilities of the organization, and the needs of the learners.

Figure 2: types of analysis and their purpose

Cited in George M. Piskurich 2006, p89

Design: the goal of this stage is to create the structure of the course (Michael Treser, 2015). Some activities to do during this stage are:

- define objectives
- decide on delivery method
- decide on training activities
- decide on ways of assessing the objectives

Objectives should be SMART and if possible SMARTER. SMARTER is an acronym derived from the acronym SMART. SMARTER means our objectives should be: **S**pecific, **M**easurable, **A**ction oriented, **R**easonable, **T**imely, **E**valuate consistently, **R**ecognize mastery (George Piskurich, 2006 p106).

Figure 3 shows different delivery methods and what they are best used for. The more the dots, the better the training will be.

	Classroom	OJT	Self-Instruction	TBT	Job Aids	Documentation
Knowledge Acquisition	••	•	••	••		•
Problem Solving	••	•	•	••	••	
Changing Attitudes	••	•		•		
Interpersonal Skills	••			•		
Knowledge Retention		••	••	••	••	

Figure 3: cross reference between delivery method and adapted competence

Cited in George M. Piskurich 2006, p94

Checklist on when to use TBT as a delivery method can be seen in appendix A.

Training activities as they should appear in an instructional plan are: pre-instructional activities, introductions, pre-tests, trainee-centered activities, instructional games, testing, embedded test, post-tests, summaries, and post-class activities (George M. Piskurich, 2006 p155-159).

Formats of assessments are: multiple choice, true or false, matching, completion, and essay format (George M. Piskurich, 2006 p168-172).

At the end of the design phase, a design document is produced that constitutes the delivery method decided, objectives, structure of the lesson plan, and type of assessments to be used. The design document is used as the main input for the develop phase of the ADDIE model.

Develop: this is where the instructional designer will be using content authoring tools to bring the concepts and ideas laid out in the course plan to life (Michael Treser 2015). George M. Piskurich, 2006 p183, advocates that the main activities for this phase are to:

- Discover the end products of development for various delivery methods.
- Develop lesson plan and learner's manual
- Develop trainee activities chosen in the design phase
- Determine and develop the right media for your training.

At the end of the develop phase we have the lesson ready for implementation.

Implementation: During this stage, the materials created during development are introduced to the target audience and the learning process starts (Michael Treser 2015). In the same article, Michael Treser states that this stage will likely include the following main steps to a greater or lesser degree:

- Training the instructors.
- Preparing the learners.
- Preparing the environment.

Once the instructors have been taught, and the learners and the environment prepared, the learning process can begin. Attention should be placed on the feedback received from the learners (Michael Treser 2015).

After the training has been presented, the next thing to do is to know if the training was effective or not. That is why we have to evaluate.

Evaluation: George M. Piskurich (2006, p268) states that you evaluate for one of two reasons: either because someone else wants to know whether the training you designed was effective or you want to know.

Despite the fact that evaluation is the final stage of the ADDIE methodology, it should be considered not as a conclusion of a long process, but as a starting point for the next iteration of the ADDIE cycle. Diligent evaluation will enable us to review and improve the educational program. Instructional Design is an iterative process, and evaluation should be carried out on a regular basis. Besides, keep in mind that to achieve best results, it is recommended to keep an eye on the quality of the course under construction throughout the development process according to the ADDIE framework, and not only at its conclusion (Michael Treser 2015).

Of course, the ADDIE model is not without its drawbacks. The linearity of the content creation process is considered its main drawback, as it can negatively affect both the course creation cost and the time requirements. This led to the development of alternative, agile course building methodologies (Michael Treser 2015). One of the most popular agile methodologies is SAM.

2.4.2. Instructional model: SAM

Created by Allen Interactions, SAM offers an instructional design approach consisting of repeated small steps, or iterations, that are intended to address some of the most common instructional design pain points, like meeting timelines, staying on budget, and collaborating with Subject Matter Experts (SMEs).

The SAM iterative process is divided in to three main phases: preparation, Iterative design, and iterative development. Allen Interactions Inc (2018) describes each of these phases on its official website as follows:

Preparation: SAM starts with the preparation phase—where you gather information and get all the background knowledge. This is intended to be a very quick phase.

Iterative Design: This phase begins with the Savvy Start, an initial collaborative brainstorm session to establish the project foundation. The Savvy Start focuses will serve as a project kickoff meeting. Throughout the Savvy Start and Iterative Design Phase, your team will be rotating through design, prototype, and review.

Iterative Development: In the Iterative Development Phase we will work through development, implementation, and evaluation together. The project will start with a design proof, move to Alpha evolve into Beta, and finalize into Gold. You will continually analyze and evaluate throughout the process. At any point if a change needs to occur, it can happen quickly to limit any risk of moving out of budget or time. Figure 4 shows an overview of the SAM model.

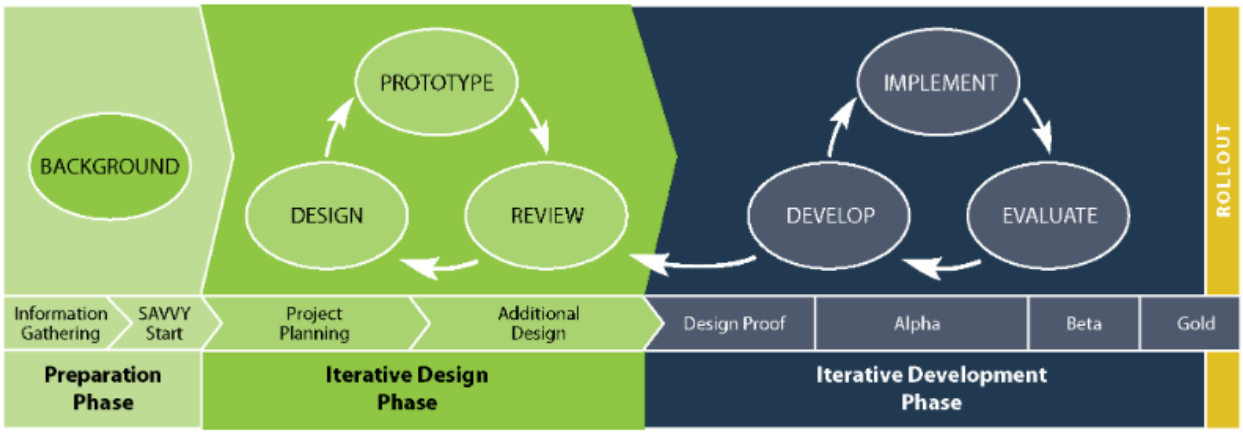

Figure 4: phases and activities of the SAM instructional design model
Copyright Allen Interactions Inc

Instructional models give instructional designers a guide to follow so that they can produce instructional products. Unfortunately, these models do not organize the instructional content in a way which is learner-centered. Instructional strategies guide the instructional designer to make the content learner centered.

2.5. Instructional Strategies

Instructional strategy help align instructional activities with the learning objectives. The instructional strategy leads us into adopting techniques such as modeling, visualization, collaboration, peer feedback, or scaffolding. These techniques allow learners to comprehend the content at the advanced levels of Bloom's taxonomy. During the content outline and instructional activities preparation stage, an Instructional Designer employs instructional strategies (Zahira Merchant, 2018).

Learning theories are the conceptual framework of how learners perceive, absorb, process, and assimilate new information. In the context of Instructional Design, the learning objective should

guide the selection of the theory (or theories). The choice of the learning theory should precede the selection of instructional strategies. (Zahira Merchant, 2018).

2.5.1. Learning theories

Learning theories are schools of thoughts backed by principles, ideas, techniques, rules that guide learning. Popular learning theories are: behaviorism, cognitivism, constructivism and socio-constructivism. To present learning theories, we are going to cite the work of Peggy Ertmer & Timothy Newby in "Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective" (1993). In this article, they inspired themselves from the work of Schunk (1991) and gave 7 questions that can be used as a guideline to differentiate between different learning theories. These questions were:

- How does learning occur?
- Which factors influence learning?
- What is the role of memory?
- How does transfer occur?
- What types of learning are best explained by the theory?
- What basic assumptions or principles of this theory are relevant to instructional design?
- How will instruction be structured to facilitate learning?

For each of the theories, we will summarize what Peggy Ertmer & Timothy Newby (1993) proposed.

2.5.1.1. Behaviorism

The goal of the behaviorist is to elicit the desired response from the learner who is presented with a target stimulus.

How does learning occur? When a proper response is demonstrated following the presentation of a specific environmental stimulus. The learner is reactive to the conditions of the environment.

Which factors influence learning? The stimuli and reinforcers used during instruction.

What is the role of memory? Memory has no role to play in learning.

How does transfer occur? Transfer occurs when situations with similar stimulus are presented to the learner.

What types of learning are best explained by the theory? It facilitates learning that involves recalling facts and automatically performing a specified procedure.

What basic assumptions or principles of this theory are relevant to instructional design? Some principles are**:** Pre-assessments of students to determine where learning should begin;

emphasis on mastering simple steps before moving to more complex; and use of reinforcement or informative feedback to impact performance.

How will instruction be structured to facilitate learning? Instruction is structured around the presentation of the target stimulus, and the provision of opportunities for the learner to practice making the proper response.

2.5.1.2. Cognitivism

They focus on the conceptualization of students' learning processes and address the issues of how information is received, organized, stored, and retrieved by the mind.

How does learning occur? Knowledge acquisition is described as a mental activity that entails internal coding and structuring by the learner. The learner is a very active participant in the learning process.

Which factors influence learning? What the learners think on during the lesson and how they code and transform information.

What is the role of memory? Memory plays an important role in learning. Learning results when information is stored in memory in an organized meaningful manner.

How does transfer occur? Transfer occurs when learner understands how to apply knowledge in different context.

What types of learning are best explained by the theory? It facilitates learning that involves reasoning, problem solving, and information processing. .

What basic assumptions or principles of this theory are relevant to instructional design? Feedback is used to guide and support accurate mental connections. Learner and task analysis is performed to check learner's predisposition for learning, and how to organize and sequence information to facilitate optimal processing. Create learning environments that promote connections previously learned material.

How will instruction be structured to facilitate learning? Making knowledge meaningful and helping learners organize and relate new information to existing knowledge in memory.

2.5.1.3. Constructivism

They claim that knowledge is a function of how the individual creates meaning from his or her own experiences.

How does learning occur? It occurs via personal interpretations of the world based on individual experiences and interactions.

Which factors influence learning? The learner and environmental factors influence learning. That is the setting should be realistic and selected task should be relevant to the student's lived experience.

What is the role of memory? Memory is always under construction as a cumulative history of interactions.

How does transfer occur? Transfer occurs by involvement in authentic task anchored in meaningful contexts.

What types of learning are best explained by the theory? It is adapted for learning of advanced knowledge in ill structured domains. .

What basic assumptions or principles of this theory are relevant to instructional design? Emphasizing on the identification of the context in which the skills will be learned and subsequently applied. Present information in a variety of different ways. Support the use of problem solving skills that allow learners to go beyond the information given.

How will instruction be structured to facilitate learning? Teaching the student on how to construct meaning; align and design experiences for the learner so that authentic relevant context can be experienced.

Omer Jomah et Al in "Micro Learning: A Modernized Education System" (2016, p103) advocates that learning is an understanding of how the human brain is wired to learning rather than to an approach or a system. It is one of the best and most frequent approaches for the 21st century learners. Strategies of learning that promote the neuroscience of learning are social learning, micro learning and gamification.

2.5.2. Gamification

The word gamification was launched in 2002 by Nick Pelling, a British IT expert, but wasn't widely used until 2010. According to Christopher Pappas, founder of eLearning Industry's Network in "How Gamification Reshapes Learning" (2016, p3) gamification is the use of game thinking and mechanics in a non-game context to inspire employees and students to get engaged in the learning process. In the same book, Chrstopher Pappas advocates that games are the answer to increasing learner's engagement. He explains what makes games effective for learning is the learners' level of activity, motivation, interactivity and engagement. This increases their fluid, as well as crystallized intelligence, something that by definition optimizes learning (Pappas & Al: 2016, p3).

In the same book, An Coppens Chief Game Changer at Gamifcation Nation Ltd, address the importance of a compelling story line with a plot where the player becomes the main protagonist and hero on a journey through a number of challenges. According to Daniel Willingham in "Why students do not like School" (2009) learning starts with paying attention and is concluded with

thought. He argues that memory is the residue of thought. Like An Coppens, he addresses the power of stories. Daniel Willingham states: "Stories are easy to comprehend because the audience knows the structure. For example, they know there must be a causal connection between actions; so, if the cause is not immediately apparent, the audience will think carefully about the previous action to try to connect it to present events". He comments that stories are interesting if reader can make inferences (deduce things or spot out implications via reasoning). Chief Game Changer An Coppens affirms that: "Gamifcation in learning works best when you make the learner think and you let them experience the consequences of their choices" (Pappas & Al 2016, p4). Karl Kapp in his article "Gamification: separating facts from fiction" (2014, p52) also insist on the importance of stories in games in this claim: "People don't play a game just for points; they play for mastery, to overcome challenges and to socialize with others. The most effective gamification efforts include more than points and badges — they contain elements of story, challenge and continual feedback as well as a high level of interactivity. These are the most engaging elements in games".

Mario Herger, founder and CEO of Enterprise Gamifcation Consultancy LLC, holds that play is important for learning. According to a report on educational games presented by Don Menn at the 2006 Summit of the Federation of American Scientists, students recall just 10% of what they read and 20% of what they hear. If there are visuals accompanying an oral presentation, the number rises to 30%, and if they observe someone carrying out an action while explaining it, 50%. But students remember 90% "if they do the job themselves, even if only as a simulation" (Pappas & Al 2016, p15).

In the book "how gamification reshapes learning", most of the authorities writing in the book, advocate that gamification in learning provides the following advantages: increases user retention, increases competition, increases learners interest, captures better the attention of the students, condenses the learning time of key ideas, enhances natural intrinsic motivation, increases the pace of learning. Instructional Designer and e-learning specialist Marina Arshavskiy advocates that games provide a safe environment for practice while teaching essential skills and knowledge (Pappas & Al 2016, p14). Gamification consultant Natalie Denmeade believes that gamification permits learners to set and understand their own goals; by re-defining failure; and by changing feedback to be fair, frequent, granular, and not fully contingent on the teacher (Pappas & Al 2016, p18).

2.5.3. Micro-learning

Omer Jomah et Al (2016, p103) define micro learning as learning in tiny chunks and short bursts of time. They advocate that it is a great way to learn in the small, goes well with mobile, and that it will only get bigger in the future. Micro learning is the process of learning through short, digestible, and well planned units (Grovo 2016, p2). Christina Drakidou (2018, p4) defines micro-learning by citing Job & Ogalo, (2012, p92) who says micro-learning "is based on the idea of developing small chunks of learning content and flexible technologies that can enable learners

to access them more easily in specific moments and conditions of the day, for example during time breaks or while on the move".

Why use micro-learning? Omer et Al (2016, p103) state that: micro-learning has become more popular due to its features such as learner centric, affordable, interactive, and well designed. Grovo (2016, p2) in the article entitled "Byte size is the right size; how micro-learning shrinks the skill gap in higher education" claims that there's an ever growing need for new and better ways to teach, learn, and train the 21st century workforce– and micro-learning is the solution. Mohamed G.S & Al (2018, p37) experiments and concludes that micro-learning method can improve student's learning ability for up to 18% compared to traditional method. The methods of micro-learning are in line with the way that the learner's brain naturally takes in information, so that the body does not get stressed-out. One of the salient features of micro-learning is that it allows the user to find exactly what he or she is looking for (Omer et Al, 2016, p104). AllenComm (2018, p2) think that: micro-learning is a response to growing learner and workplace complexity. AllenComm (2018, p2) also advocates that micro-learning is an important modality for us to consider when developing our training strategy.

Grovo (2016, p7) states that, the main advantages of micro learning are: better engagement, better retention, and better application. These 3 components; represent the holy grail of all educators. Omer et Al (2016, p104) like Grovo advocate that micro learning is the solution to educators since it is fun and engaging, requires little effort from the learner, and involves simple and narrow topics. Mohamed G.S & Al (2018) advocate that micro-learning grants learners to access the newest information whenever, wherever, and in the format that they require. AllenComm (2018, p5) advocates that the main advantages of micro-learning are focused lessons and flexibility. They also add that, micro-learning can play a very good role as reinforcement.

Micro-learning is not useful when: people need to acquire/learn complex skills, processes, or behaviors; people need relevant practice - and feedback on performance (Omer et Al, 2016, p104).

Grovo (2016, p10-14) propose the following guide lines for effective implementation of micro learning:

- It should be short (no lesson video should take more than 3 minutes)
- The units of learning should be small and granular
- Use story
- Make content recursive
- Find application points and use them
- Use show and tell

Christina Drakidou (2018, p18) summarizes the main technologies used in micro-learning by stating that: "All researchers refer to the use of interactive web 2.0 tools that draw and hold the

learners' attention easily. The tools mentioned in the relevant literature are namely: slideshows, videos (Zhao et al, 2010), infographics (Omer, 2017), podcasts (Sharma, 2017; Bruck et al, 2012), pictures (Souza & Amaral, 2014; Zhang et al, 2016), check lists (Eldridge, 2017) and eBooks (Omer, 2017). Blog and social media (mainly Twitter and Facebook) posts (Souza & Amaral, 2014), wikipages (Souza & Amaral, 2014; Bruck et al, 2012), external links to Open Educational Resources, also simulations, branching scenarios and games (Sharma, 2017) frequently appear in the micro-learning literature."

The production of web 2.0 tools like simulations and games require specific scientific methodologies. Producing such tools requires knowledge in the domain of software engineering and software development methods.

2.6. Software Development methods

Software development methods are guidelines used to manage a software project. In this part of our work we will be presenting 2 agile methods for software development: SCRUM, and XP.

2.6.1. XP

According to agile alliance (2018), Extreme Programming (XP) is an agile software development framework that aims to produce higher quality software, and higher quality of life for the development team.

2.6.1.1. When to use XP

XP is applicable in the following circumstances:

- Dynamically changing software requirements
- Risks caused by fixed time projects using new technology
- Small, co-located extended development team
- The technology you are using allows for automated unit and functional tests

2.6.1.2. Life cycle of XP

According to Scott W. Ambler the XP life cycle is divided into 5 phases: Exploration Phase, Planning Phase, Iterations to Release Phase, Productionizing Phase, and the Maintenance Phase. A summary of each phase of the life cycle by Scott Ambler that cites the work of Beck (2000) and others is given below:

Exploration phase: The first phase that an XP project experiences is the Exploration phase (Beck, 2000), encompassing the initial requirements modeling and initial architectural modeling aspects of the agile software development lifecycle. This phase includes development of the architectural spike and the development of the initial user stories.

Planning phase: Following the Exploration phase is the Planning phase (Beck, 2000), the purpose of which is for you and your customers to agree on a date by which the smallest, most

valuable set of user stories will be implemented. When you are planning, you will brainstorm what the tasks for a given user story are, and will produce a task card for each task (Wake, 2002). A task card typically lists a text description of what you need to do to accomplish the task.

Iteration phase: The Iterations to Release Phase (Beck, 2000) encompasses the primary effort of an XP project, more typically referred to as construction iterations or simply iterations, as this is where your major development efforts including modeling, programming, testing, and integration occur. The Figure that follows depicts the iteration phase of XP

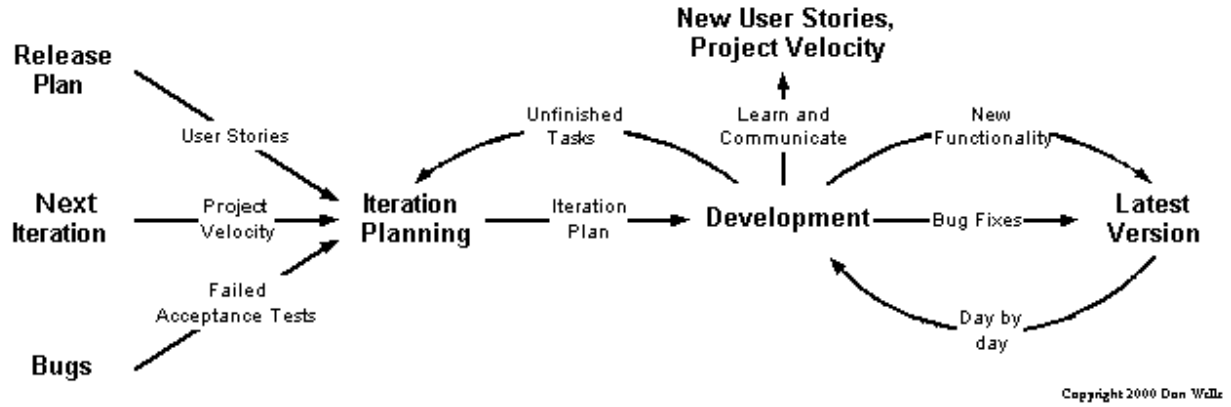

Figure 5: schematic representation of XP's iteration phase

Cited in Dan Walle (2000)

Productionizing phase: XP's Productionizing phase (Beck, 2000) is very close to the deployment phase in the agile software development lifecycle and encompassing the Acceptance Testing and Small Releases.

Maintenance phase: The XP Maintenance phase (Beck, 2000) is the normal state of XP projects because you keep evolving them over time. This phase encompasses the Planning, Iterations to Release, and productionizing phases for releases 2 through N of your system.

A schematic representation that summarizes the XP life cycle is given as follows

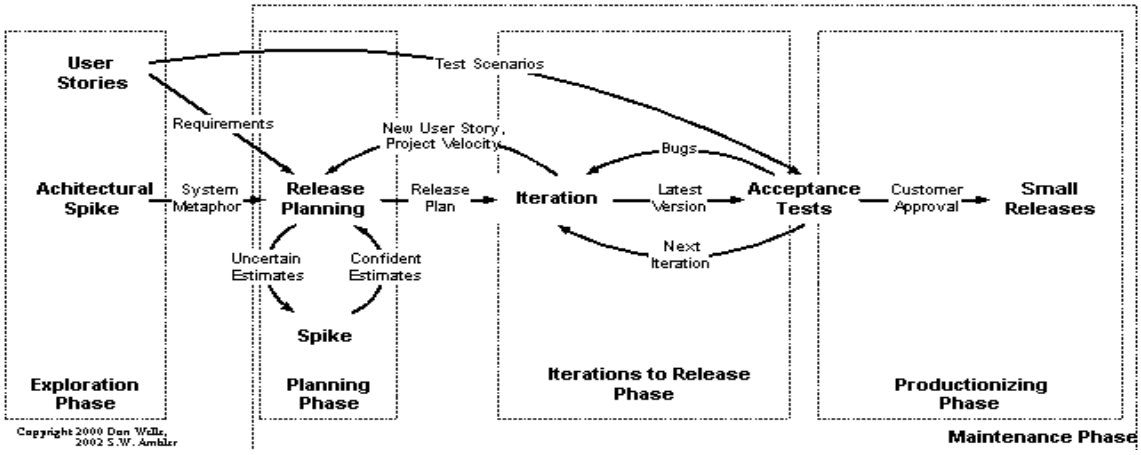

Figure 6: schematic representation of XP's life cycle

2.6.2. SCRUM

According to agile alliance (2018) Scrum is a process framework used to manage product development and other knowledge work. Scrum is empirical in that it provides a means for teams to establish a hypo dissertation of how they think something works, try it out, reflect on the experience, and make the appropriate adjustments.

2.6.2.1. When to use SCRUM

Scrum is best suited in the case where a cross functional team is working in a product development setting where there is a non-trivial amount of work that lends itself to being split into more than one 2 - 4 week iteration.

2.6.2.2. Life cycle of SCRUM

The SCRUM life cycle presented below is taken from the SCRUM body of knowledge 3rd edition by Tridibesh Satpathy & Al (2017). The phases of the SCRUM life cycle are: initiate, plan and estimate, implement, review and retrospect, release. The phases in scrum and the main activities in each phase are shown in Figure 7.

Phase	Fundamental Scrum Processes
Initiate	1. Create Project Vision 2. Identify Scrum Master and Stakeholder(s) 3. Form Scrum Team 4. Develop Epic(s) 5. Create Prioritized Product Backlog 6. Conduct Release Planning
Plan and Estimate	7. Create User Stories 8. Estimate User Stories 9. Commit User Stories 10. Identify Tasks 11. Estimate Tasks 12. Create Sprint Backlog
Implement	13. Create Deliverables 14. Conduct Daily Standup 15. Groom Prioritized Product Backlog
Review and Retrospect	16. Demonstrate and Validate Sprint 17. Retrospect Sprint
Release	18. Ship Deliverables 19. Retrospect Project

Figure 7: SCRUM phases and their respective activities

Cited in Tridibesh Satpathy & Al (2017, p14)

Initiate Phase

1. Create Project Vision—in this process, the Project Business Case is reviewed to create a Project Vision Statement that will serve as the inspiration and provide focus for the entire project. The Product Owner is identified in this process.
2. Identify Scrum Master and Stakeholder(s)—in this process, the Scrum Master and Stakeholders are identified using specific Selection Criteria.
3. Form Scrum Team—in this process, Scrum Team members are identified. Normally the Product Owner has the primary responsibility of selecting team members, but often does so in collaboration with the Scrum Master.
4. Develop Epic(s)—in this process, the Project Vision Statement serves as the basis for developing Epics. User Group Meetings may be held to discuss appropriate Epics.
5. Create Prioritized Product Backlog—in this process, Epic(s) are refined, elaborated, and then prioritized to create a Prioritized Product Backlog for the project. The Done Criteria is also established at this point.
6. Conduct Release Planning—in this process, the Scrum Core Team reviews the User Stories in the Prioritized Product Backlog to develop a Release Planning Schedule, which is essentially a phased deployment schedule that can be shared with the project stakeholders. Length of Sprint is also determined in this process.

Plan and Estimate Phase

7. Create User Stories—in this process, User Stories and their related User Story Acceptance Criteria are created. User Stories are usually written by the Product Owner and are designed to ensure that the customer's requirements are clearly depicted and can be fully understood by all stakeholders. User Story Writing Exercises may be held which involves Scrum Team members creating the User Stories. User Stories are incorporated into the Prioritized Product Backlog.
8. Estimate User Stories—in this process, the Product Owner clarifies User Stories in order for the Scrum Master and Scrum Team to estimate the effort required to develop the functionality described in each User Story.
9. Commit User Stories—in this process, the Scrum Team commits to deliver Product Owner approved User Stories for a Sprint. The result of this process would be Committed User Stories.
10. Identify Tasks—in this process, the Committed User Stories are broken down into specific tasks and compiled into a Task List.
11. Estimate Tasks—in this process, the Scrum Core Team estimates the effort required to accomplish each task in the Task List. The result of this process is an Effort Estimated Task List.
12. Create Sprint Backlog—in this process, the Scrum Core Team creates a Sprint Backlog containing all tasks to be completed in a Sprint as part of the Sprint Planning Meeting.

Implement Phase

13. Create Deliverables—in this process, the Scrum Team works on the tasks in the Sprint Backlog to create Sprint Deliverables. A Scrum board is often used to track the work and activities being carried out. Issues or problems being faced by the Scrum Team could be updated in an Impediment Log.
14. Conduct Daily Standup—in this process, everyday a highly focused, Time-boxed meeting is conducted referred to as the Daily Standup Meeting. This is the forum for the Scrum Team to update each other on their progress and any impediments they may be facing.
15. Groom Prioritized Product Backlog—In this process, the Prioritized Product Backlog is continuously updated and maintained. A Prioritized Product Backlog Review Meeting may be held, in which any changes or updates to the backlog are discussed and incorporated into the Prioritized Product Backlog as appropriate.

Review and Retrospect Phase

16. Demonstrate and Validate Sprint—in this process, the Scrum Team demonstrates the Sprint Deliverables to the Product Owner and relevant stakeholders in a Sprint Review Meeting. The purpose of this meeting is to secure approval and acceptance from the Product Owner for the Deliverables created in the Sprint.
17. Retrospect Sprint—in this process, the Scrum Master and Scrum Team meet to discuss the lessons learned throughout the Sprint. This information is documented as lessons learned which can be applied to future Sprints. Often, as a result of this discussion, there may be Agreed Actionable Improvements or Updated Scrum Guidance Body Recommendations.

Scrum is an iterative process and an iteration of between 1 to 4 weeks is called a sprint. After a sprint a specific deliverable is produced. A schematic representation of a scrum sprint is depicted in Figure 8 that follows.

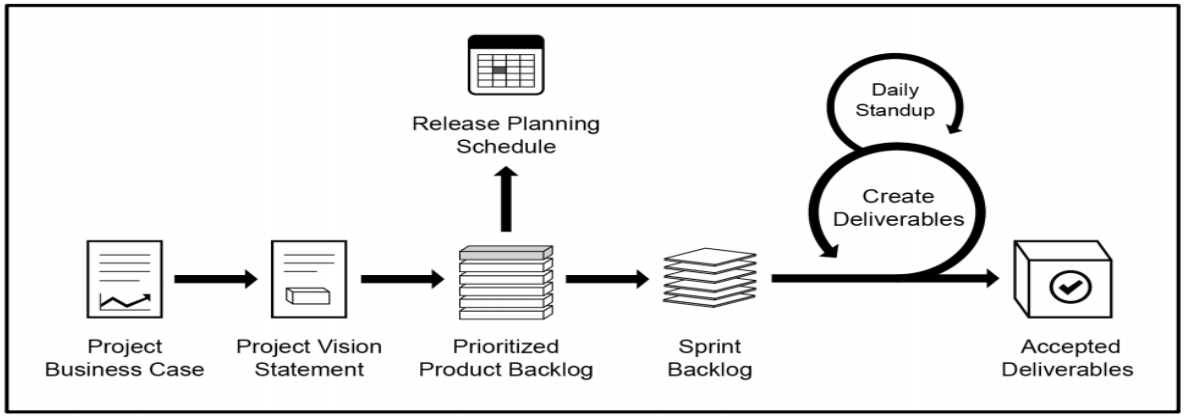

Figure 8: Scrum flow for one sprint

Cited in Tridibesh Satpathy & Al (2017, p2)

2.7. Game Engines

A game engine is a software development environment designed to develop video games. Partha Sarathi Paul et Al (2012, p245) defines a game engine as: a platform of doing common game related tasks like rendering, physics related computation and input, so that developers (artists, designers, scripter and other programmers) can focus on the details that make their game unique. Game engines are the way to go to properly develop a game and have full control over it. They do require advanced developers and experience, as they're highly customizable and the possibilities are endless. They save a lot of time by offering many preset modules, libraries, effects, and tools so that you don't have to create everything from scratch (Hady ElHady, 2018). Partha Sarathi Paul et Al (2012, p245) alternatively defines game engines as collection of reusable components that can be manipulated to bring a game to reality.

Partha Sarathi Paul et Al (2012, p248) provides the following tools as examples of game engines: cry engine, Hero engine, source engine, Unity, Unreal and vision engine. Hady ElHady (2018) in his article cites the top 10 game engines used in 2018 in the following order: Unreal, Unity, Godot engine, cry engine and more.

Adobe flash cs6 was once considered as one of the most powerful game engines and has been used to build a lot of games. But, since 2012, flash cs6 is no more supported and thus not the best choice to use as game engine since documentation and solutions to bugs may be very difficult to find.

Unity is a game engine not as powerful as flash, but well supported and documented till date. Currently, 34% of the top 1000 free mobile games are made with Unity; it has an instant play mode for rapid editing and iteration, and a powerful animation system (Hady ElHady, 2018). It has a free version that is powerful enough to produce stunning games.

Chapter 3: Methodology

3.1. Choice of Methodology

To develop the tutorial, we detected the necessity of 3 domains of knowledge: instructional design, instructional strategy, and software engineering. We decided to use a model or framework for each domain of knowledge. The ADDIE model was used for instructional design, gamification and micro-learning for instructional strategy, and SCRUM for software engineering. We thus integrated gamification and the agile method SCRUM into ADDIE to have a new model that shares the strength of all the models and covers the weakness of each called GADDES (Gamified Analysis Design Development and Evaluation with SCRUM).

One of reasons we chose ADDIE was its flexibility (cyclic and iterative). Merrienboer (1997) supports this with the following claim: "phases may be listed in a linear order, but are in fact highly interrelated and typically not performed in a linear but in an iterative and cyclic fashion". Another reason is that, it is a placeholder for other purpose driven models. Clark (1999) states "ADDIE is a 'plug and play' model when different models for each phase can be plugged in".

The first reason why we chose SCRUM was because its process control and iterative delivery makes projects adaptable and open to incorporating change. Another reason was because of its early and continuous delivery of high value requirements, and continuous feedback.

Micro-learning was chosen because it focuses learning, does not stress the body, and divides learning into narrow, simple, and digestible units. Gamification was also chosen because it increases motivation, activity, interactivity, and engagement.

Figure 9 depicts how the integration of ADDIE, instructional strategies and SCRUM took place.

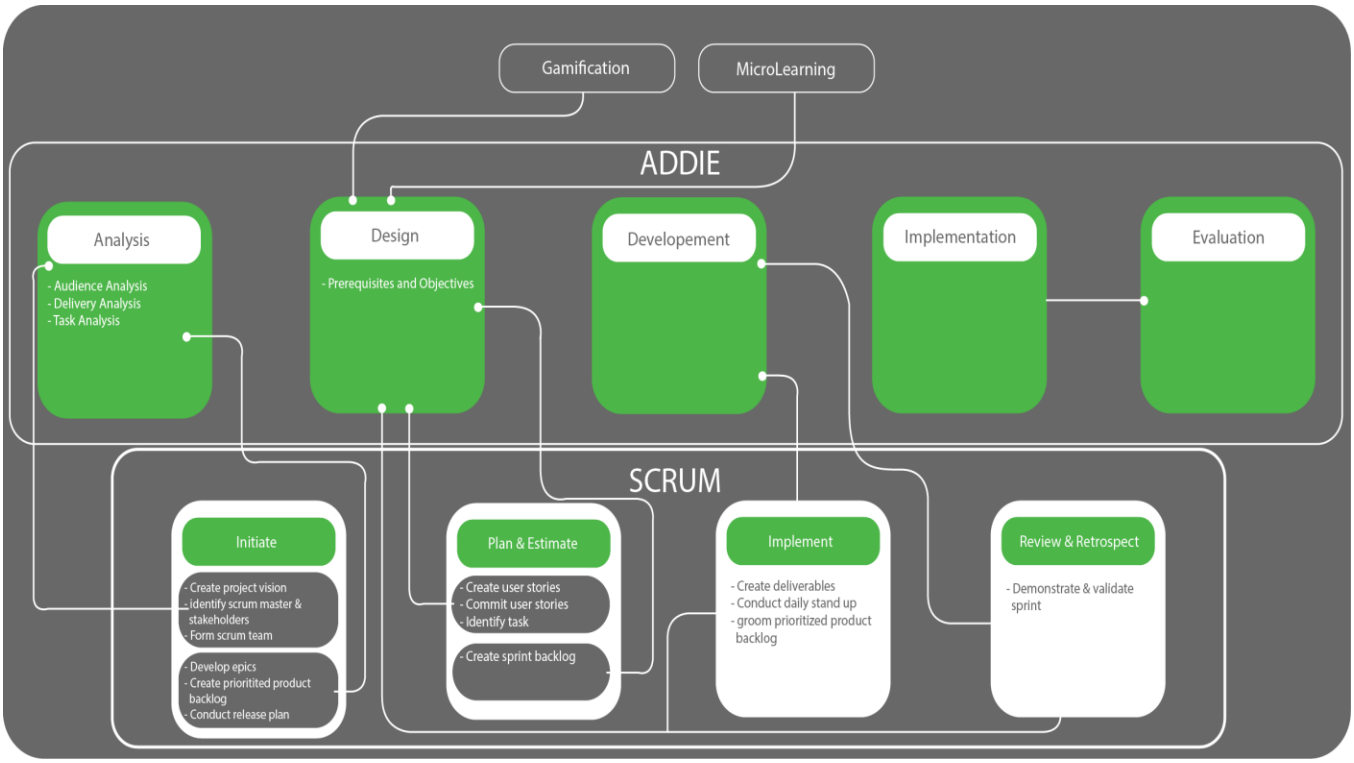

Figure 9: Process of integrating ADDIE, SCRUM and Gamification

From the figure we notice that the SCRUM phase initiate is divided into 2 activities and integrated in the analysis phase of ADDIE. We see also that gamification and micro-learning are integrated during the design phase. Activities done during the plan and estimate, implement and review phases of SCRUM are also added into the design phase; because, the design phase will be iterative and will provide and test deliverables that are not source code. We further notice that the implement, and review phase in SCRUM will be integrated in the development phase. This is where deliverables in the form of documentations, learning materials, and source code will be iteratively produced and tested. Finally there is a merge between of the evaluation and implementation phase.

The final model called GADDES gotten after the integration is given in Figure 10 below:

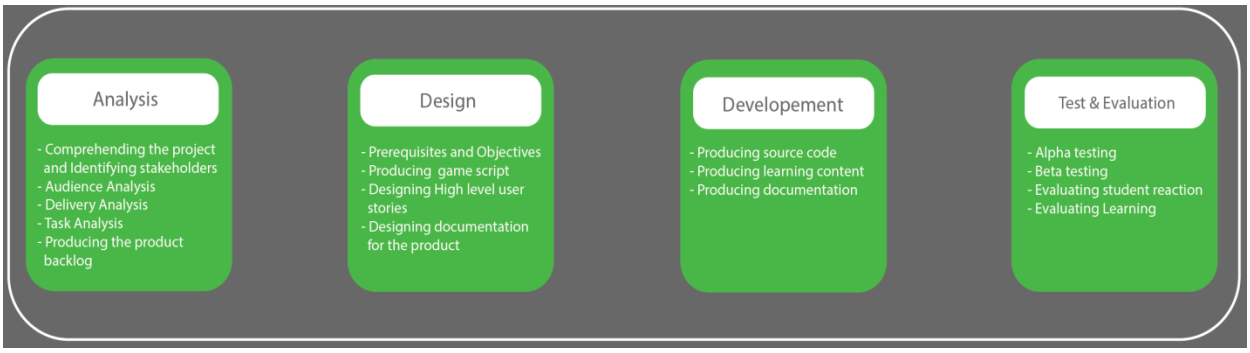

Figure 10: GADDES model derived from integrating ADDIE, SCRUM, and Gamification

Figure 10 shows a 4 stage model with the following phases: Analysis, Design, Development, and Test & Evaluation. In the analysis phase, the following activities are conducted: identifying the business need and stakeholders; analyzing the audience, analyzing the delivery place, and analyzing the subject matter. Activities of the design phase are: detecting objectives and prerequisites; producing the game script; designing high level user stories, designing product documentation. Activities in the development phase are: producing source code; producing learning content; and producing documentations. The final phase Test and evaluation has 4 activities: alpha test; beta test; evaluating student reaction; and evaluating learning.

A schematic representation that summarizes the project flow using GADDES is given in Figure 11 below:

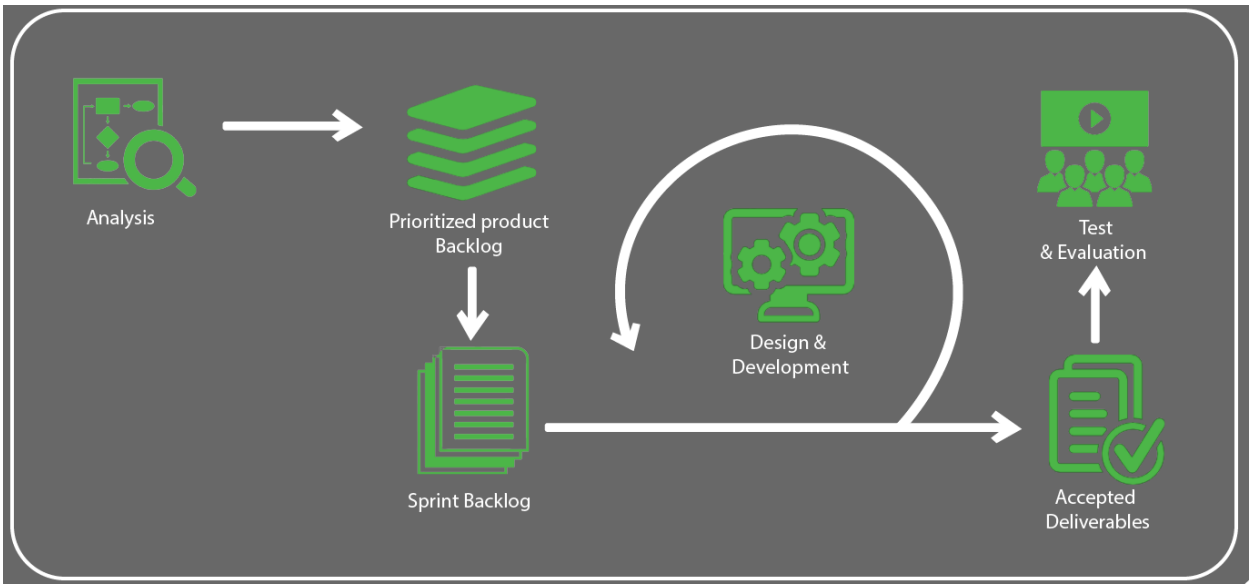

Figure 11: Schematic representation of project flow using GADDES model

Figure 11 shows that an analysis is performed to produce a product backlog. A meeting is then held with the necessary stakeholders to validate these requirements. After validation, a subset of the backlog or a subset of a deliverable on the backlog is chosen to be what will be created and delivered during a sprint. The item delivered can be a design deliverable or a development deliverable. During the process of creating deliverables, daily stand ups are conducted. As sprints are going on, deliverables are tested and the product backlog is being updated if necessary. After looping until all deliverables on the product backlog are exhausted, the product is put into use and evaluated to detect other modifications that can be done to ameliorate it. Depending on the type of error detected during test and evaluation, we can jump to any phase that will help fix it. A description of each type of test done for each phase in the project flow is given in Appendix E.

3.2. Analysis

During our analysis phase, we started by trying to comprehend the project and form a team. Then we decided to analyze the following: the audience, leaning environment, and the task. We finally then produced a product backlog that represents the main deliverables of our system.

3.2.1. Comprehending the project and Identifying stakeholders

To understand the project, we had a series of meetings with the client. People that had an interest in the project or who were involved were considered as stakeholders to the project. End users were stakeholders who were supposed to exploit the project. The scrum master was chosen based on ties and commitment to the project. The team members were chosen based on the diverse skills needed and their readiness to participate.

3.2.2. Audience analysis

Our end user was made up of two groups: form five students and biology teachers. After identifying our target population, we defined the aims for our analysis for each group in the target population. For the learners, our aims were to have an appraisal of the following: their learning preferences, average age, use of ICT tools, and their difficulties in learning (most especially the lesson on cassava transformation).

While for the teachers, our aims were to have an appraisal of the following: the obstacles they face on teaching the transformation of cassava, their use of ICT tools and the amount of control they may want to have over the content of such an instructional product.

After bringing out our intent for each group in our target population, we then decided to choose a sample for our target population. The sample was chosen based on 2 criteria: proximity to researcher, and type of institution (private school or public school). The learners and teachers sample was taken from GBPHS and HIHS Yaounde.

Since the student population was large, we decided to use a quantitative methodology to collect and analyze data. A questionnaire was developed based on the objectives defined for the student target population. 298 copies of this questionnaire were collected from the students with 197 coming from GBPHS and 101 coming from HIHS. For the teachers, we used a qualitative methodology for collecting and analyzing data. A face to face interview was conducted with 8 teachers, 3 from HIHS and 5 from GBPHS Yaounde. The questions used during the interview and data collection can be seen in Appendix B of this dissertation.

After collecting the data for the students, we used Excel 2010 to build an analysis tool that permitted us to enter the collected data and then automatically deduce information that will permit us to measure the aims defined for our learner target population. Thematic analysis was used to analyze the data collected from the teachers.

3.2.3. Delivery analysis

Learning environment here refers to any milieu where teaching and learning occurs. This milieu can be physical or virtual. In our study, we focused on 2 aspects of the learning environment: the classroom and the delivery technologies the students are more versed with.

We studied the classroom with the intent to know two things: whether their classrooms were adapted for deploying TBT or if there is any possibility for deploying a TBT in their institutions. To have this information, a qualitative study via observation and interview was done in the schools of our sample population. Firstly, the study focused on observing if classrooms had electricity, computers or any ICT tool. And secondly, whether the institution had electricity, projector, and a computer laboratory where the instructional product could be deployed for an acceptable number of students.

We studied the delivery technology in general for we wanted to know the different technologies that can be used to disseminate such an instructional product. We noticed that technologies that could easily facilitate the dissemination of such a tutorial where of 3 main types: web-based, desktop-based, and mobile-based. To know which delivery technology to use for our sample, we decided to include in our survey, questions that will help us know the technologies the students are more versed with. So that, we could reduce the effort needed to learn and use the tutorial.

3.2.4. Task analysis

The subject matter here was the transformation of cassava into its end-products. Our main aim here was to know the KSAs (knowledge, skills and abilities) that make up the content to assimilate.

To do so, we decided to get assistance from biology teachers in our sample and SMEs (Subject Matter Experts) for specific end-products. To get the required information needed to reach the aforementioned aim, an interview using a model of questions was done with the SMEs and teachers. These questions can be consulted at Appendix B of this dissertation.

3.2.5. Producing the product backlog

To produce the product backlog, the scrum master tapped from the previous work done during this phase and other source documents to develop epics and documents needed to make the tutorial ready. The MoSCoW (“Must have,” “Should have,” “Could have,” and “Won’t have”) prioritization scheme was used to categorize the deliverables.

3.3. Design

The design phase is where decisions on certain aspects and explanations on how certain deliverables will be achieved were made.

3.3.1. Prerequisites and Objectives

The prerequisites for us had 2 aspects: first of all, what the learner is expected to know to be able to learn how to transform cassava in to each of the targeted end-products. And secondly, what they are expected to know to be able to use the tutorial. For what they are expected to know to learn the transformation of cassava into its end-products, we interviewed 4 biology teachers in our sample and SMEs. For the basic skills to be able to use our tutorial, we analyzed our delivery method and other aspects of using such a tutorial.

To craft the objectives, we relied on the expertise of the teachers in our sample. We used the prescriptions provided by George Piskurich (2006, p119-126) on how to construct good objectives. We also deduced a topical outline for each type of transformation.

3.3.2. Producing the game script

The game script here comprised of two things: a prose that described the different scenarios of the game, and a flow chart that portrayed the possible decisions and navigations in the game. The game script was derived by merging a good narrative and flow with elements of game thinking and mechanics. Micro-learning was integrated by making sure the scenes are short and target one small piece of knowledge.

For the choice of game elements and game mechanics, we decided that the game will contain elements like goal, rules, objectives, conflict, challenge, feedback, rewards, achievements, levels, story, points, leaderboards and replay. Game dynamics like racing, collecting, allocating, strategy, mystery and action were chosen at different scenes of the game story.

3.3.3. Designing the functionality play level 1

We used the game script to break down level one into user stories. The user stories were written following the formalism of who, what, and why presented in the Scrum guide book (2017, p189). A detailed scenario of the user story was made by the SCRUM team to act as a blueprint from which task to be assigned will be derived. Class diagrams for each user story were also produced.

3.3.4. Designing the functionality view content

To design this functionality, we first of all had to decide on the formats (video, audio, textual, etc.) the content was to have, then refined the functionality into user stories and wrote their detailed scenarios.

Since 85% of the students' preferred video content, we decided that our main scaffold will be in the form of videos. Other scaffolds like images, text, were included to give choice to students and to suit a variety of learning preferences. We decided on two categories of video content: one that the learner could hear and see the transformation process as it is going on, and another one that explained the process without the learner seeing how it is done. To integrate micro-learning principles, no video was expected to be more than 3 minutes.

The functionality view content was refined and user stories derived from it. Detailed scenarios of each user story was written by the SCRUM team to act as a blueprint from which task to be assigned will be derived. Class diagram was also produced.

3.3.5. Designing the functionality update content

Any content that could be modified by the teacher was stored in the database where with the help of the user manual, a teacher can easily replace, add, or remove content. A user story for this functionality and a scenario was also written.

3.3.6. Designing the functionality view leaderboard

The user story and scenario of this functionality was written down and class diagram produced.

3.3.7. Designing documentations

The necessary documents were produced incrementally as the different parts of the tutorial was developed, implemented, and tested. There were two big documents to produce, each one having its target audience.

The system documentation which targeted other developers and the outline for this document was produced based on the study of other developers' documentation.

The users documentation was divided into 2: end users' and instructional designers' documentation. End users documentation was further divided into: trainers' and learners' documentation. Trainers' documentation included how to install the product, how to modify the content in the product, system requirements for installation, proposed lesson plans to make the most of the tutorial, etc. The student guide explained how to play the game, how to easily finish the scenes, how to get rapid help and more.

3.4. Development

During development, the scrum team chose certain elements on the product backlog and worked on it for 3 weeks. This was called the sprint backlog. Even though the main deliverable was source code, other deliverables were learning contents, and documentations.

3.4.1. Producing learning content

Our varieties of content came from different sources and where fabricated differently. Demonstrative videos on how to transform cassava into the targeted end-products of the lesson where to be downloaded from YouTube or any source, and then edited to make sure any superfluous data is removed to make sure micro-learning principles are respected. Presentation videos were created by merging text and images and sound to present the tools and activities involved in the transformation of cassava into its end-products. Textual content was gotten from Biology teachers and SMEs. The textual content was divided into small digestible units to make

sure principles of micro-learning were integrated. Questions used for evaluation were gotten from teachers and SMEs.

3.4.2. Producing source code

To create source code, the team engaged into the chosen technology. We started by installing the necessary tools needed, then following tutorials on how to develop a game with the chosen game engine. The scrum team was divided in pairs of two and each pair had a task to perform. The sections of the tutorial needed to accomplish their task were followed by each pair. Daily standups were conducted with respect to check points which were done twice a day; the first 15 minutes of the day, and after 4 hours of work. Check points were defined by the scrum master.

The questions prescribed by scrum for daily stand up meetings where used to conduct the meetings. Solutions to problems where not discussed instantly, they were discussed later on during work hours. Technical problems was first of all rapidly discussed in the team, if no one in the team could provide a solution, an external expert was contacted by the specific pair having the problem.

Each deliverable was tested as it was being developed by the pair, and later tested by an external tester. Code was structured using object oriented techniques and other guides provided by the chosen game engine that facilitate integration. Refactoring was performed by each pair to prevent duplicate code and to facilitate understanding of the code.

Once an epic on the product backlog was ready, it was shown to the product owner for validation.

3.4.3. Producing documentations

To produce the system documentation, elements of the analysis, design, development, test case and other features that describe the system were combined. For the learner's documentation, the elements of the game were studied and provided to the learner while guidelines to make the most of the lesson were gotten biology teachers and SMEs. The trainers guide was also inspired by biology teachers, SMEs and other instructional designers.

3.5. Test and Evaluation

During this phase, we performed the following 2 activities: an alpha test and a beta test. During the beta test, we evaluated student reaction to the tutorial and their learning. We evaluated for 2 reasons: firstly, to get feedback from the students and teachers so that we can know the types of modifications to be made on the tutorial. The second reason for evaluating was to know if the tutorial in any form enhanced learning. To get student feedback from the tutorial, we used a reaction sheet, and to evaluate learning, we used structural questions.

3.5.1. Alpha test

Alpha test had 2 main objectives: evaluate usability of the tutorial and evaluate instructional flow and content of the tutorial.

To conduct the alpha test, we invited the following: 2 biology teachers who played the role of experts in teaching biology, an SME specialized in the transformation of cassava into "garri", 2 IT teachers that played the role of instructional designer and critic for the ergonomics (usability) of the tutorial. We then installed the tutorial in a few computers and invited 5 students to play with it so that we can get feedback from the experts.

By tapping into the criteria of Bastien & Scapin to evaluate the usability features of a tool, we built an evaluation grid that will be used to evaluate the tutorial. We also used some advice from George M. Piskurich (2006, p241) to build a series of questions that will help us capture certain aspects from our audience and run the alpha test effectively. Some of the questions are presented below.

- Are the writings visible and clear enough?
- Are Transitions comfortable?
- Is feedback to trainee sufficient?
- Is the content relevant to trainee situation?

A detail question list and the evaluation grid are provided in Appendix C.

3.5.2. Beta test

This is a kind of test that is performed with the exact parameters and within the exact environment where the training will take place. We decided to do a beta test so that we can check the logistics of our delivery environment; the effectiveness of our lesson plan: assumptions made on prerequisites, timing, effectiveness of activities; the attitude of the students towards the training, feedback from the students and to later evaluate the effectiveness of the tutorial.

The sample students chosen for our beta test was not random. It was made up of students who failed biology in both terms. This sample was divided in two groups: a control group whose fail mark was between 7 and 9 and an experimental group whose fail mark was between 1 and 6. The experimental group was to learn with the help of the tutorial while the control group was to learn without the help of the tutorial (using a traditional method).

To get feedback from the test, we produced a form that will help us capture certain metrics. The form was made up of questions divided in 4 sections. The sections and some questions in each section are presented below. For a complete list, see Appendix D.

- **Logistics of delivery environment**
  - ✓ Was there any complain about the components of the computers?

- ✓ Can the tutorial be installed on the machines of the laboratory?

- **Effectiveness of lesson plan and content**
  - ✓ Did the activities take much time than planned?
  - ✓ Was there any student previous knowledge we did not capture?
- **Learner's attitude**
  - ✓ Was the game fun? Why?
  - ✓ Did they intuitively know what to do?
- **General**
  - ✓ Which difficulties did you face during this lesson?
  - ✓ What changes do you think can be made on this game?

3.5.3. Evaluating student reaction

To capture student reaction, we produced a reaction sheet. The difference between the form used during the beta test and the reaction sheet used here is that: the form during beta test was filled by the instructional designer, while here; the reaction sheet is filled by the student. This sheet was filled only by students of the experimental group.

The reaction sheet was produced using a framework provided by George M. Piskurich (2006, p274-275). The reaction sheet for the tutorial can be seen in Appendix E.

3.5.4. Evaluating learning

The evaluated students were those chosen for the beta test. Learning was evaluated at 2 levels: the first level was in the game. This was done only for students in the experimental group. If a learner successfully completed a level of the game then he had learnt something. The second level of the evaluation was a hand written test whose aim was to test higher levels of competence in the bloom's taxonomy. This evaluation was performed by both the control and experimental group. The hand written formative evaluation can be seen in Appendix E.

Chapter 4: Results and Discussions

4.1. Analysis

The results obtained for each task performed during analysis is given below.

4.1.1. Comprehending the project and Identifying stakeholders

The goal of this project is to enhance learning on the transformation of cassava into its end-products.

The customer for the project is HTTC Yaounde. The role of voice of the customer and SCRUM master was performed by Nfor Ngala Nelson (Mr.) because of his connection to the project that will motivate his commitment and availability. The main users of this tutorial are form five students and biology teachers in Cameroon since the tutorial is made to suit the Cameroonian syllabus and context. The SCRUM team was made up of Developers, SMEs in the transformation of cassava into its end-products, Biology teachers, and instructional designers.

4.1.2. Audience analysis

Our audience was made up of 2 groups: form five students of GBPHS and HIHS, and Biology teachers of GBPHS, HIHS, and other SMEs.

After analyzing the data collected from 298 students of which 40% of them were male, we noticed that the average age of form five students in our sample was 15. We also noticed that most students preferred to learn this topic by experiencing it in real life. Table 4.1 shows the relative frequency distribution table for each learning preference presented in the questionnaire.

Table 4.1: relative frequency distribution showing percentage for each learning preference

reading	Watch video	Listen audio	Play game	image	Real life	discussion
158	253	179	247	185	266	209
53%	85%	60%	83%	62%	89%	70%

Figure 12 below shows a representation of the above table as a bar chart.

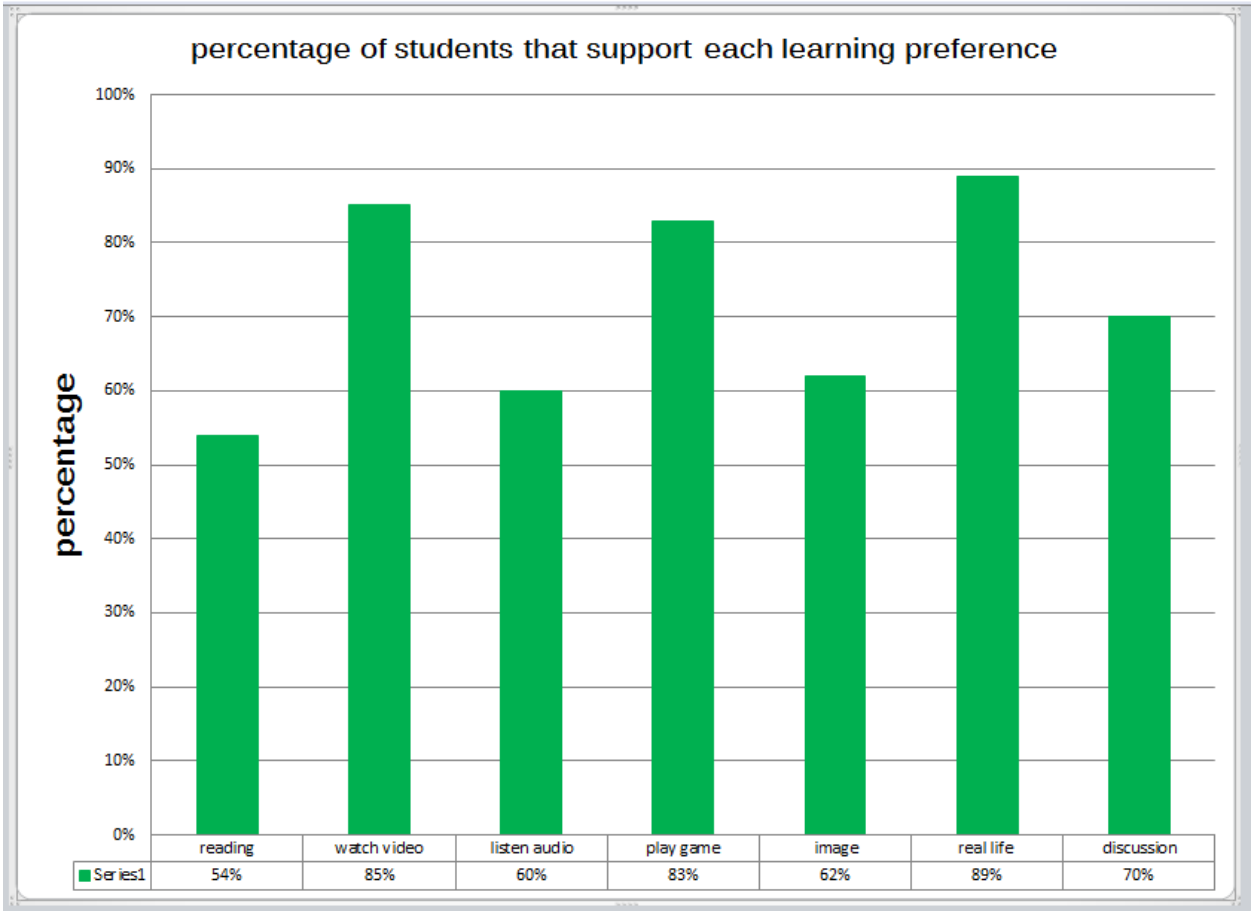

Figure 12: bar chart showing relative frequency of each learning preference

From the Figure 12, we notice that 85% of students preferred to learn how to transform cassava into its end-products by watching a video on the topic while 89% preferred learning by getting involved in the process. Some 83% of them indicated that a game that teaches this concept will be of great use. Reading how to transform cassava into its end-products even though had a percentage above 50, registered the lowest percentage.

The student's accessibility to the computer, registered an interesting percentage. About 70% of the students confirmed to either own a computer or have an opportunity to use a computer at home. A total of 171 students attested they use their computers to play, 173 confirmed they use it to watch videos, and some 58 said they use it to read. We noticed that the main use of the computer for these students was to play or watch videos.

The main difficulties registered by the students in learning how to transform cassava into its end-products was that of no opportunity to practice. Some 72% of the students advocated that no opportunity to practice will be their main obstacle to understanding such a lesson while 55% said too much notes to copy will be their main problem. Other suggestions of obstacles provided by

students where turning around 2 themes: disturbance from other students during the lesson and consecration of more time in watching of television series than studying their lessons.

The other part of our audience was made up of teachers and SMEs. After analyzing the information gotten from biology teachers, the main obstacles to them for teaching such a lesson was turning around the following 2 themes: impracticability of effectively experimenting such a lesson and the lack of didactic resources suited for such a lesson. Most of them advocated that such a lesson will sprout intrinsic motivation in the students if they are told they will by the end of the lesson fabricate popular food items like "garri" or "bobolo". These teachers claimed that the impractical nature of the lesson is not just because of the absence of the didactic resources necessary to experiment the lesson, but also because of the class sizes and the reluctance of other teachers to help control and guide the students during such practical lessons.

As far as IT proficiency of the teachers is concerned, 6 out of the 8 teachers interviewed stated their proficiency in the use of ICT resources like the computer was good.

All the teachers insisted that they will like to have control over the content of such a tutorial. They explained that every teacher is different and works with respect to the level of the students in front of them. They said they will want to be able to change the questions and lecture notes of such a tool to place their own content.

4.1.3. Delivery analysis

We looked at 2 main aspects when we were conducting the delivery analysis: the classroom, and the delivery technology.

The delivery technology was studied quantitatively by getting data on student's accessibility to ICT tools like computers and phones. About 70% of the students claimed to either own a computer or have one they can use at home. More than 95% of them claimed to have seen or use a computer. Amongst the uses of the computer, 171 asserted they use the computer to play while 173 said they use the computer to watch videos. About 20% said they use the computer to communicate or conduct an online research. About 38% of the students declared they have smart phones and the main use of these phones where to communicate and search for information online. Very few attested they use their smart phones to read or play or watch videos. About 15% attested to have access to internet connection and from our observations in the respective schools; internet connection was either absent or not stable. We thus opted for a desktop based application running on the Windows operating system since all the schools and students were more versed with the Windows operating system.

We also analyzed the classrooms and other appropriate areas where such a lesson could take place using techniques of observation and interview. We noticed that amongst the five form five classrooms in GBPHS Yaounde, none had a working wall plate, and the disposition of the classroom was not adapted for TBT. The same situation was noticed in the classrooms of HIHS.

Through interview, we discovered that the GBPHS has 2 computer laboratories, one for the Francophone section and the other for the Anglophone section. We got interested in the laboratory adapted for the Anglophones and observed that this laboratory had 40 running computers. The school also could provide a generator and a projector. Checking other study areas of the school, we discovered that the best place to run a TBT in GBPHS Yaounde or HIHS was the computer laboratory.

4.1.4. Task analysis

The data collected from the SMEs and teachers was then analyzed, and we discovered that there are generic KSAs needed for the transformation of cassava into its end-products, and there are KSAs that are peculiar to a specific type of transformation. We also noticed that some tools were necessary for all types of transformation while other tools were peculiar to a specific transformation.

The SMEs informed us that the transformation can be done with local tools or they can be done with more sophisticated tools. The type of tools used was dependent on 2 things: the quantity to produce, and whether it is produced by an industry or a local individual or community. The SMEs informed us that each step in the transformation process has a specific purpose and can be achieved with a variety of tools.

They illustrated this by taking the transformation of cassava into “garri”. They explained that the five main steps of transforming cassava into “garri” are: cleaning, washing, grating, dewatering, and frying. They then expounded that cleaning can be achieved using various tools like a cleaning machine, or by peeling with a knife or any item that can be used to achieve the purpose of cleaning. The same idea was exposed for washing and the other parts that make up the transformation of cassava into “garri”.

With these specifics from the SMEs, we turned to the teachers and the MINISEC 2014 schemes of work to get the scope of the lesson on each type of transformation. We then decided to focus on the transformation of cassava into its end-products based on a local community or individual while mentioning that of an industry. We also focused on 2 main categories of knowledge: the tools and resources needed for each transformation, and the steps needed for each type of transformation.

4.1.5. Producing the Product backlog

To conclude the analysis phase, we identified the different deliverables needed to meet the business need and then produced a product backlog. This backlog is given in table 4.2 below. The numbers at the priority level helps us know which deliverable has the most priority amongst deliverable in the same priority level of the MoSCoW prioritization scheme. The lower this number, the higher the priority; 1 has a higher priority than 2, and so on.

Table 4.2: prioritized product backlog and respective done criteria

Deliverable	Priority level	Done criteria
Game script	Must have (1)	Contains a flow chart that shows various decisions making and logical paths a user can take and a prose part that describes what happens. Include best practices of gamification.
Play level 1: transform cassava to garri	Must have (2)	All scenes in the level are complete
View content	Must have (3)	Demonstration and presentation videos are present for transforming cassava into garri and can be watched via the tutorial. Videos respect best practices of micro-learning.
Update content	Must have (4)	There is a possibility to change the videos
View leaderboard	Should have (1)	The 5 best players can be displayed
Product Documentation	Should have (2)	System documentation and user documentation. Should have indispensible features of each type of documentation.
Play level 2: transform cassava to bobolo	Should have (3)	All scenes in the level are complete

We focused on the "must have" and "should have" features and documentations of the tutorial. Other features like play level 3, play level 4, etc. will be included in future versions.

4.2. Design

The goal of our design phase was to make decisions on certain aspects and explain how certain deliverables will be achieved. The time for each sprint varied, but the average time for a sprint was 3 weeks.

4.2.1. Prerequisites and Objectives

From the analysis, we decided to narrow our goal by choosing 2 specific end-products: "garri" and "bobolo" and use a blend of TBT and classroom training.

After discussing with SMEs and biology teachers, we came to the conclusion that apart from being able to see, read, and listen, there is really no special know how a student needs before taking the lesson on transforming cassava into its end-products. The fact that the students are schooling and are in form 5 implies they already possess all the basic skills cited above.

For basic knowledge needed to use our tutorial, the learner is expected to have basic skills on how to use the computer since we are using a TBT delivery method with the main media being the computer. The basic skills was based on the manipulation of the mouse; click, drag and drop, and the manipulation of the keyboard; mostly the use of directional keys.

The objectives gotten for the tutorial on how to transform cassava into “garri” and “bobolo” are given in the following way:

At the end of the lesson, the student should be able to:

- Write in an ordered manner all the steps to follow when transforming cassava into “garri” by an individual or a local community.
- State all the resources needed at each step in the transformation process of cassava into “garri” based on the lesson seen in class.
- Associate to each step a local tool used to aid the transformation of cassava into “garri” in a local community or by an individual.
- Describe the purpose of each tool used at each step of the transformation of cassava into “garri”.
- Detect from an imaginary environment all the resources found in it that can aid in each step used in the transformation of cassava into “garri” seen during the lesson.
- Write in an ordered manner all the steps to follow when transforming cassava into “bobolo” by an individual or a local community.
- State all the resources needed at each step in the transformation process of cassava into “bobolo” based on the lesson seen in class.
- Associate to each step a local tool used to aid the transformation of cassava into “bobolo” in a local community or by an individual.
- Describe the purpose of each tool used at each step of the transformation of cassava into “bobolo”.
- Detect from an imaginary environment all the resources found in it that can aid in each step used in the transformation of cassava into “bobolo” seen during the lesson.

We then deduced the following outline for each type of transformation:

I. Overview of the transformation steps
II. Tools needed
III. Alternative tools
IV. The transformation process

4.2.2. Producing the Game script

The prose part of the game script described the story of the game and how game elements and dynamics were integrated into the different scenes of the levels. Each level had at least 4 basic scenes which are:

1. A first scene (called scene 1) that gives the description of the **problem to solve** for that level

2. A second scene (called scene 2), that puts the player in a situation where he has to dodge obstacles and collect the **tools needed for the targeted transformation**.

3. A third scene (called scene 3) that requires of the player to **show his mastery** of the transformation by answering the questions of a maven (expert or whiz).

4. And a fourth scene (called scene 4) that permits the player to use the tools acquired and resources found in his environment to solve the problem defined in the first scene (**practice on how to transform cassava into the targeted end-product**).

Scene 4 is how we intended to answer our first research question (***How can one give students the opportunity to practice the transformation of cassava into its end-products while making it less expensive and risk free?)***; because, scene 4 is where students will virtually simulate the cassava transformation process.

This solution was less expensive since we do not have to buy resources. Also, students can practice as many times as they want without an increase in cost. Moreover, the students can make mistakes without hurting themselves. Of course, this simulation will not be as effective as a real life practice since psychomotor objectives will not be met, but it will at least predispose the student with basic knowledge and attitudes needed to have an edge when transforming cassava into the targeted end-product. Thus, a virtual simulation is how we intend to address our first research question.

Elements of game thinking and game mechanics were integrated in each scene as follows.

The element of story was included at the first scene of each level to explain the main problem to solve. Also, the story conveyed conflict, rules, mystery, transitions and objectives for each scene.

The second scene of each level had the following elements:

- Rules like collecting all the tools provided.
- Points when a tool is collected or when a zombie is killed.
- Life of player, which implies the player, can die.
- Conflict and challenge from the zombies and different antagonist.
- Feedback when zombies die or tools are collected.
- Failure when zombies suck out all the life in the player.
- Levels of difficulty were provided to allow players to navigate from less easy situations to more challenging situations and to increase the chances of replaying the game.

Game dynamics like collecting was included when player accesses the tools. Action and strategy was included via dodging and killing of zombies. Also, mechanics of mystery was included by not allowing the player to know where zombies will come from and also by randomly changing

the positions from which the zombies will appear. While dynamics of racing was included by adding a time limit needed to dodge all the zombies and collect the tools provided in the scene.

Scene 3 contained the following game elements: life, points, story, challenge (when player's ability to transform cassava into "garri" is challenged by the sage of the village), and failure since player can choose a wrong answer. Levels were also provided for this scene to manage the level of difficulty and the element of feedback was used when a sound indicates failure and when the remediation for failed questions is presented to the player at the end of the scene. Components of game dynamics included were: racing since each question had a limited amount of time to be answered and discovery since the questions and answers were randomly chosen and shuffled from database of 29 questions.

Scene 4 had elements of story, life, rules, feedback when the right transformation tools and resources are associated, failure when life becomes zero and levels. The components of game dynamics included are: allocating; when player associates the right resources and tools to the right step, pattern recognition, race; when player has to figure out the right combination of tools and resources before the end of a timer.

Other components of games like leaderboards, replay-ability, rewards where integrated in the game. A detailed description of the game script can be seen in appendix F.

The use of TBT was the first step to answering our second research question (***How can one augment attention and retention of students?***) since educators advocate that the integration of technology into the teaching-learning process would enhance comprehension and creativity in the learner. If comprehension and creativity is boosted by technology, then technology indirectly or directly improves attention and thought; since, they are indispensible for comprehension and creativity. And since memory is the residue of thought, thinking will consequently breed retention. Thus, using a technology based approach indirectly increased student attention and retention.

The second step to increase student attention and retention was the integration of game thinking and game mechanics into the lesson. Most educators advocate that games increase student motivation and engagement. They also state that games do not only increase student creativity and problem solving skills, they also reduce their fear of failure and increase their confidence. Fear of failure and self-doubt being one the greatest obstacles to students' progress. The above elements directly or indirectly imply an increase in student attention and retention. Moreover, because there is no fear of failure, games provide opportunities for continued practice. And since practice makes memory long lasting (practice does not only makes perfect, it also makes permanent), games help increase student retention. Furthermore, the fact that a good game has elements of story helps increase retention. This is because stories respect the principle of causality which promotes connectedness of ideas and most people know this structure in stories. Thus, when an event happens, they know there must be a causal connection which prompts them

to start thinking on the previous events to try to connect it to the present event or stay alert for future events to see the connection. Since memory is the residue of thought, stories thus help increase student retention. Staying alert means being attentive, that implies story also increases student attention.

Thus, using TBT and integrating gamification into the lesson was how we intended to increase student attention and retention.

Flow charts that illustrate navigations and decisions in the game were produced for the navigation from level to level and for scenes. The flow chart for scene 3 is given on figure 13 below:

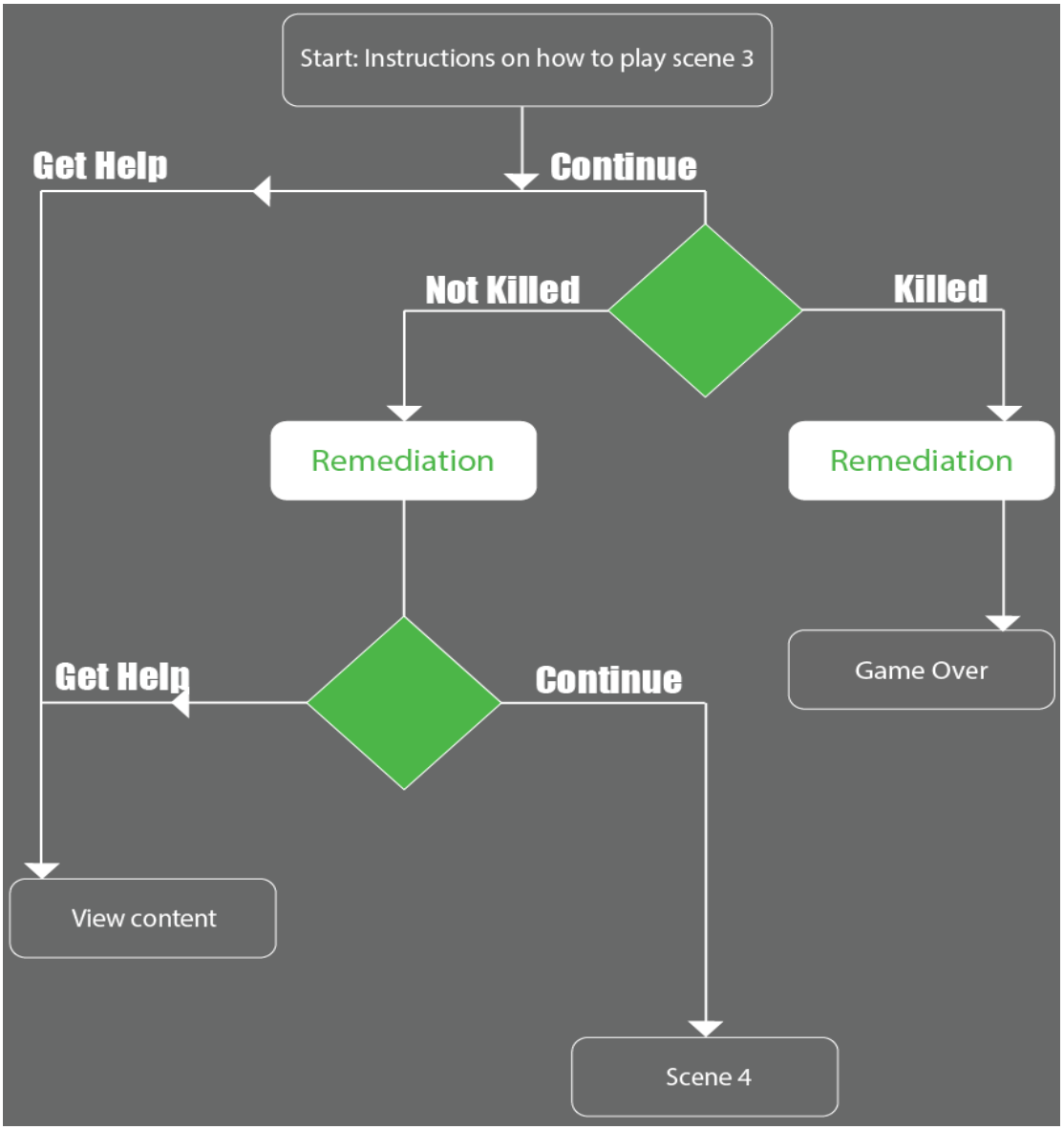

Figure 13: Flow chart illustrating the different decisions made in scene 3

From figure 13, we notice that the player can get access to content while playing this scene or can play the scene till death or till he wins without getting access to content. We also notice that whether he is killed or not, a remediation is provided for the questions failed during this scene. Moreover, when player gets help and access content, there is no way to come back and continue at that scene; he must start back at the beginning. For more detailed and complete information on flowcharts in the game script, visit appendix F.

4.2.3. Designing the functionality play level 1

The high level user stories for play level 1 are the following:

- As a player, I want to play scene 2; so that, I can know the tools needed to transform cassava into garri.
- As a player, I want to play scene 3; so that, I can prove that I have knowledge on how to transform cassava into garri.
- As a player, I want to play scene 4; so that, I can put in practice my know-how on transforming cassava into garri.

A scenario and class diagram for each user story is given below.

Scenario and class diagram for Scene 2

1. The system places the player at the start of the scene
2. The player displaces his character.
3. The player dodges obstacles and barriers on his way
4. If player collides with obstacle, the system reduces his life by a given unit.
5. The system increases a timer as player is advancing to collect tools
6. If player collects a tool, the system increases his points
7. If players life reduces to zero, the system kills the player
8. If the timer reaches the maximum, the system kills the player
9. If player collects all the tools and reaches the door to the village, the system takes him to the next scene.

The class diagram for this scenario is given in figure 14 below.

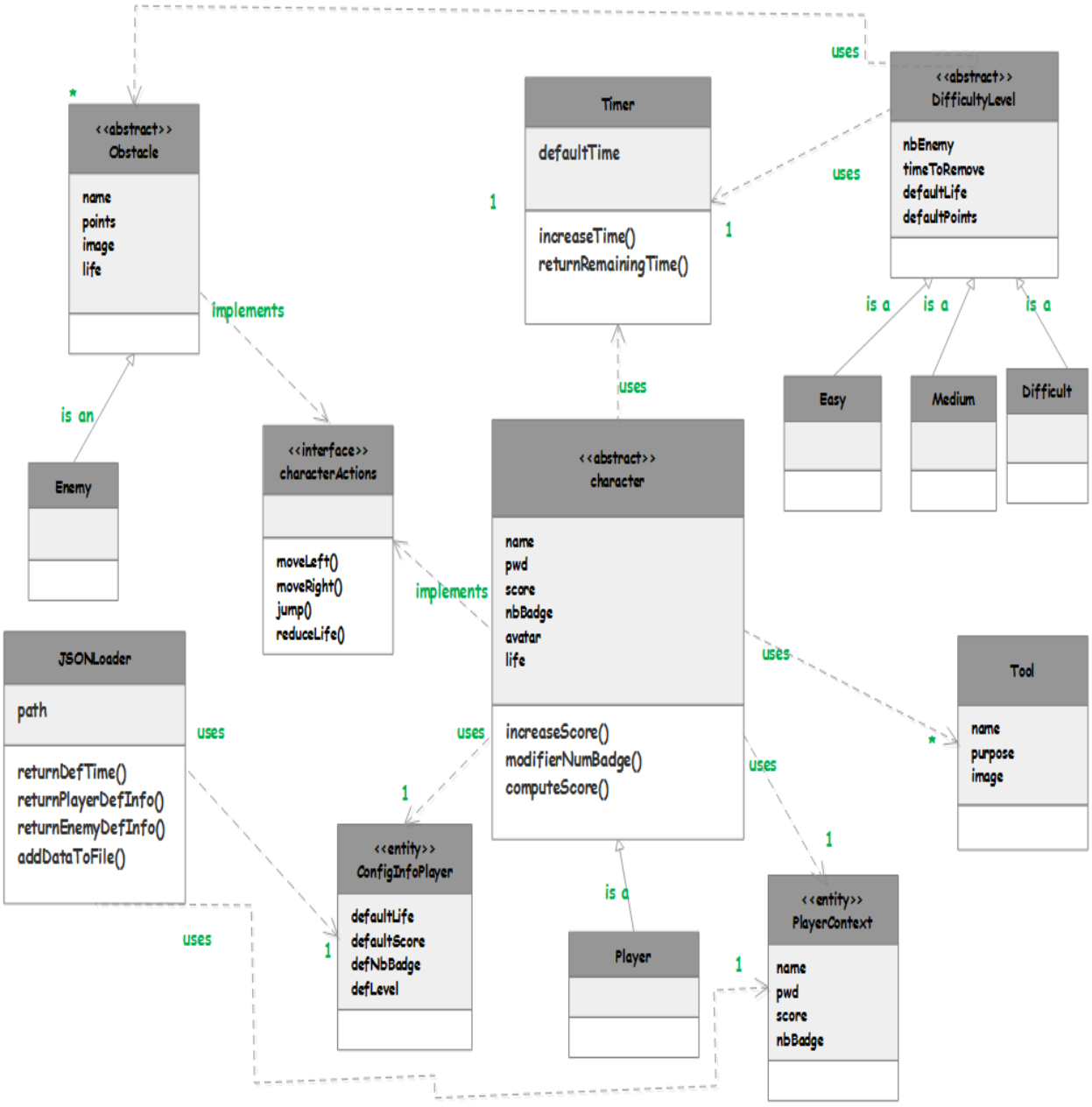

Figure 14: Class diagram for scene 2

Scenario and class diagram for Scene 3

1. The system randomly displays a question and its answers
2. The system increases a timer while waiting for players' choice
3. If player chooses an answer, the system provides feedback on the correctness of the answer
4. If answer is correct, the system increases players point
5. If players answer is wrong, the system reduces the life of the player by a given unit

6. If timer elapses without player making any choice, the system provides feedback and reduces player's life.
7. If player chooses to get help from the genie, the system takes him to the view content functionality.
8. The system keeps on displaying questions randomly and waiting for answers until player's life is finished or a certain amount of questions is asked.
9. The system displays a remediation that is made up of questions failed by the player.

The class diagram for this scenario is given in figure 15 below

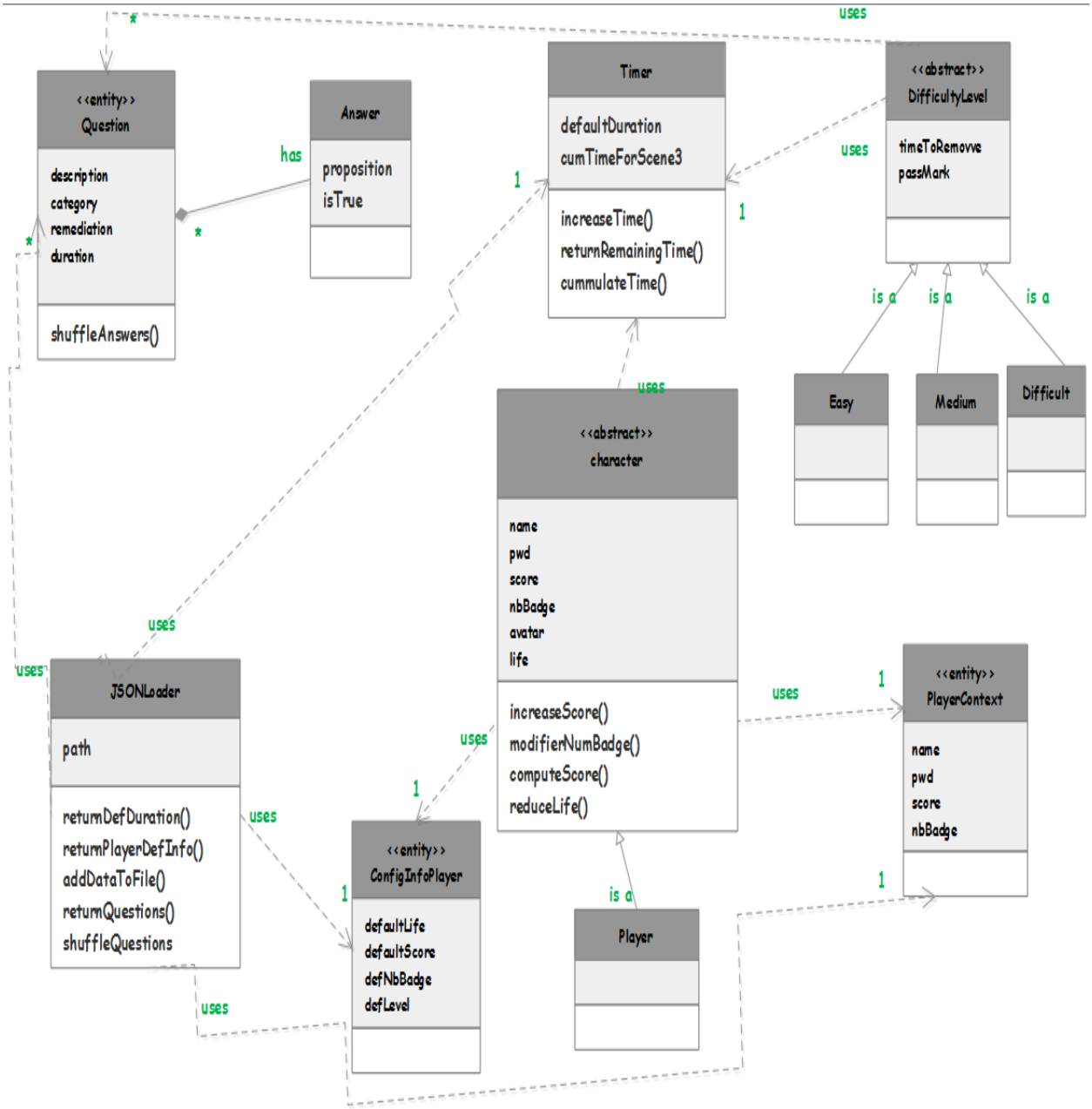

Figure 15: Class diagram for scene 3

Scenario and class diagram for Scene 4

1. The system displays the tools collected and other resources.
2. The system starts a timer.
3. The player combines the tools and the resources one step at a time.
4. If the combination is wrong, the system reduces player's life by a given unit.
5. If combination is correct, the system increases the points of the player and displays the output of the combination
6. If timer elapses, the system kills the player
7. If player's life reduces to zero, the system kills the player
8. If all combinations are correct, the system displays a question.
9. If player answers the question correctly, the system increases his points.

The class diagram for scene 4 is given in figure 16 below

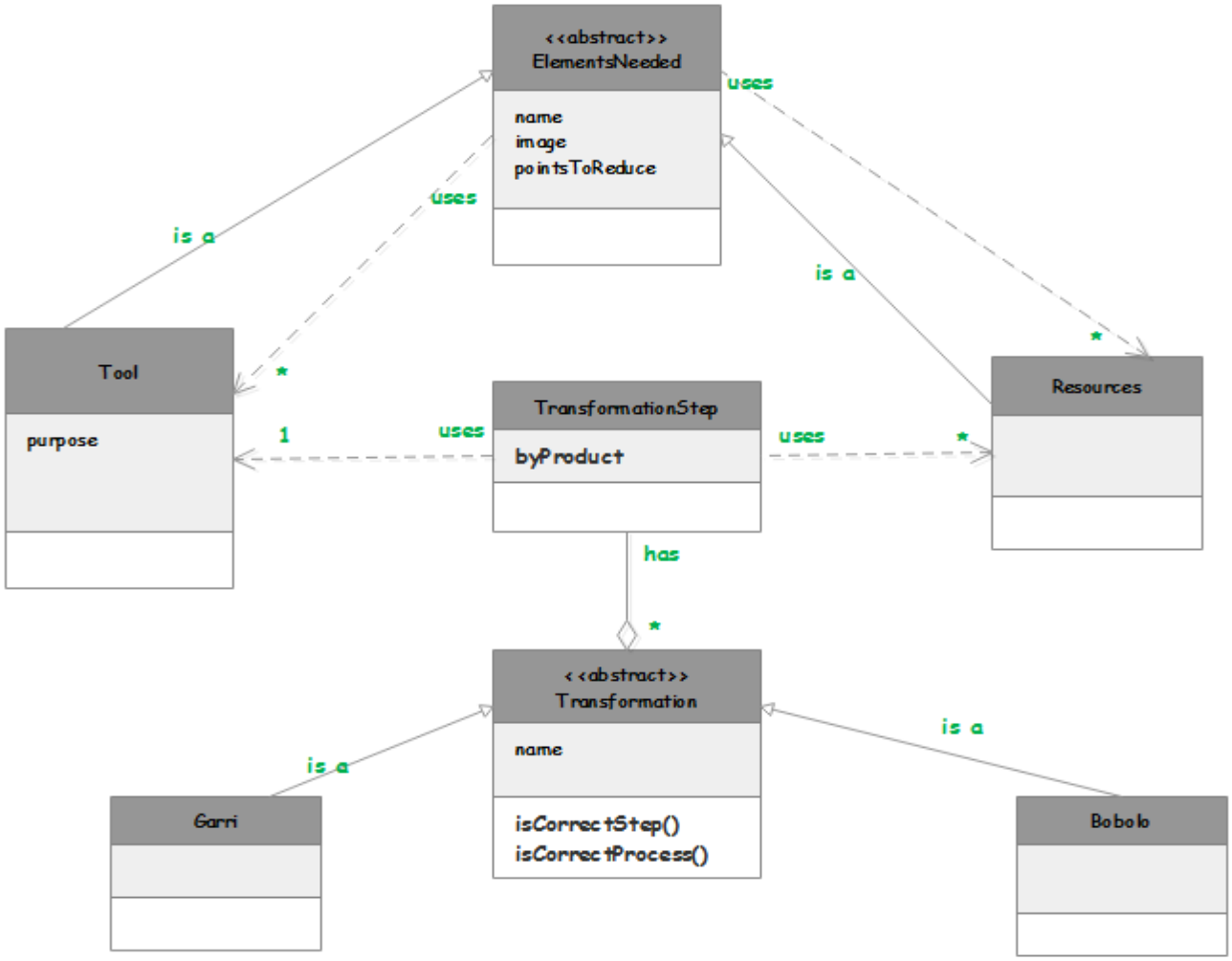

Figure 16: Cross section of class diagram for scene 4

4.2.4. Designing the functionality view content

The scenario for the functionality view content is:

1. The system displays the different contents
2. The player chooses the content to view
3. The system displays the content.

Figure 17 shows the class diagram for view content.

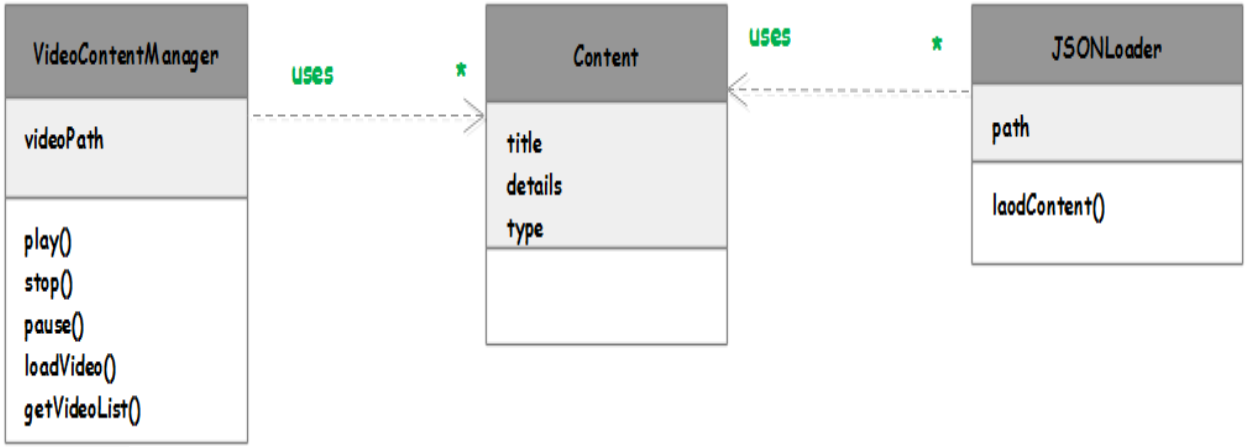

Figure 17: Class diagram for view content

4.2.5. Designing the functionality update content

The scenario for this functionality is given below:

1. The trainer locates where the content is stored in the tutorial
2. If content to update is video, then trainer adds his own video content. Trainer can delete existing video content if he wants.
3. If content to replace is questions, trainer must make a copy of the existing question file and change the question and the answers while respecting the format of the file. The name of the file should not be changed. Then the trainer should delete the old copy and keep the new copy.
4. If content to replace is textual, trainer replaces the existing file with his own textual content. The file he is using should have the same name and format as the previous file.

4.2.6. Designing the functionality view leaderboard

The scenario for this functionality is given below:

1. The player request to take a look at the leaderboard
2. The system collects the top 10 scores and displays them to the player.

Figure 18 shows the class diagram for functionality view leaderboard

Figure 18: Class diagram for view leaderboard

4.2.7. Designing documentations

The plan on the different documents to produce is represented in figure 19 below

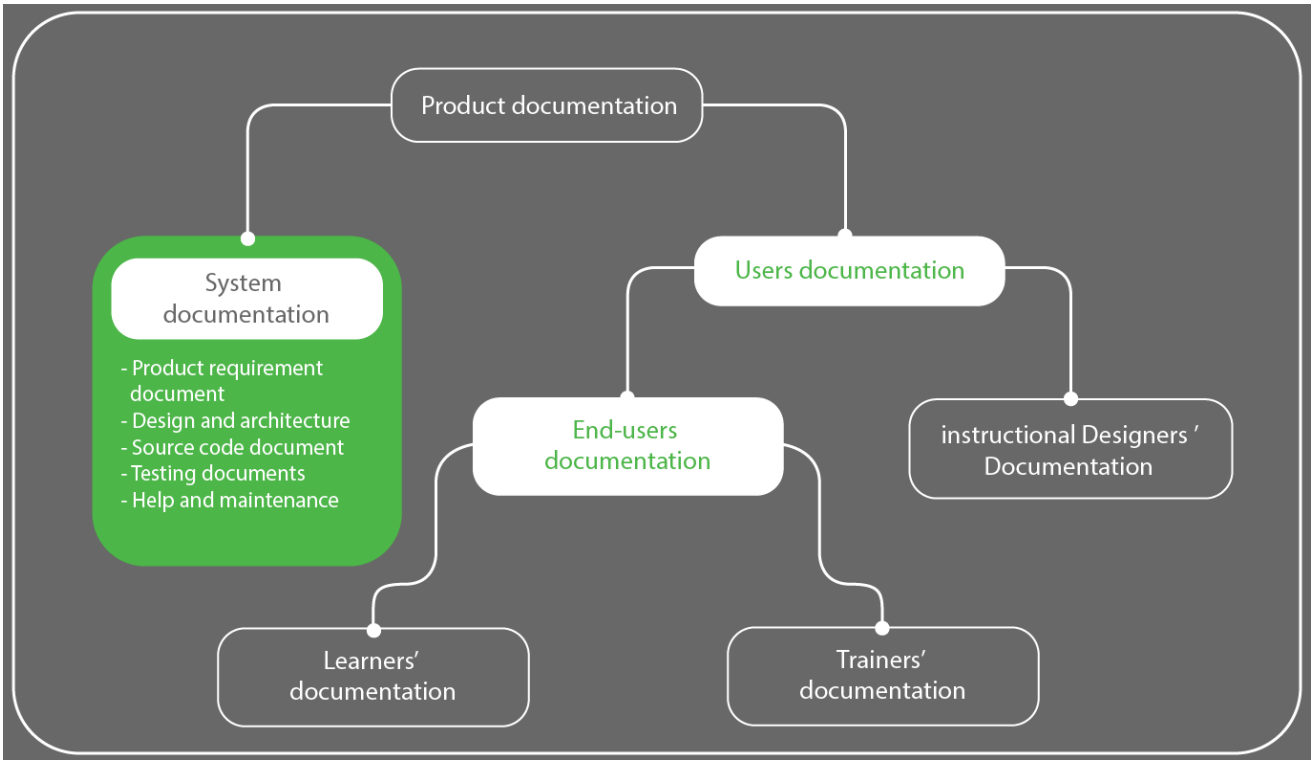

Figure 19: Documentations to produce and cross section of a plan

The purpose of the system documentation is to help other develops understand and work on the product. The purpose of the learners and trainers documentation is to help each actor make the most out of the tutorial. While that of instructional designer is to help other instructional designers understand and evaluate the pedagogic aspect of the tutorial.

4.3. Development

4.3.1. Producing learning content

We had 4 demonstrative videos: “homemade garri”, “industrial production of garri”, and “local community production of garri”. Figure 20 below shows icons of these videos.

Figure 20: Icons of demonstrative videos

None of the videos were more than 3 minutes. Homemade garri is a video that last 3mins and 18s, industrial production last 2mins and 53s, while local community last 1min and 20s. Watching the “local community garri” video is sufficient, but we decided to add other videos for repetition and variety.

For presentation videos, they were 4 since our outline had 4 different sections. Figure 18 below shows the icons for these videos.

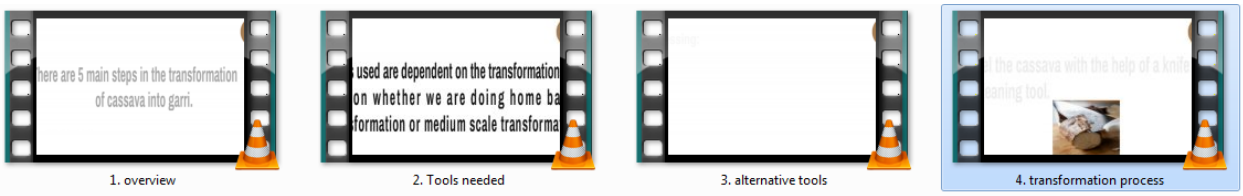

Figure 21: Icons of presentation videos

The first video (called overview) takes 53s, the second (called tools) takes 49s, next is (alternative tools) takes 1mins and 38s, and the last one (transformation process) takes 58s. The video “tools needed” and “transformation process” is enough to mastery. We added the other videos to enhance learning via repetition.

The division of the content into small pieces that focus on a particular goal and the amount of time taken to consume the content was one the main techniques we used to address our third and final research question (***How can one make learning happen faster?***). Another way was by tapping into the numerous advantages of integrating game elements and mechanics into the lesson. Thus, the integration of micro-learning principles into the game scenes and during the development of the learning materials made sure learning happens faster.

4.3.2. Screen capture of source code output

Screen captures of the outputs produced by the source code are given below:

Figure 22: screen shot showing the different items in the start menu

Figure 23: screen shot depicting the place where player chooses his level

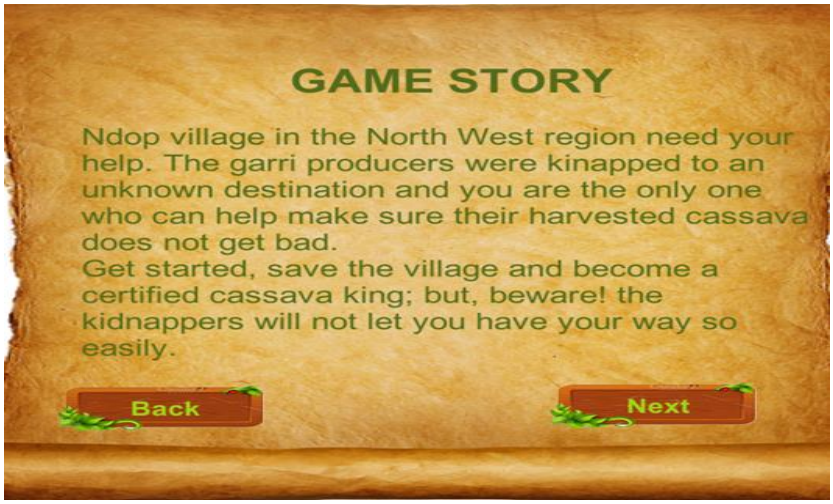

Figure 24: screen shot showing the story for the level

Figure 25: Panel that gives player possibility to choose level of difficulty

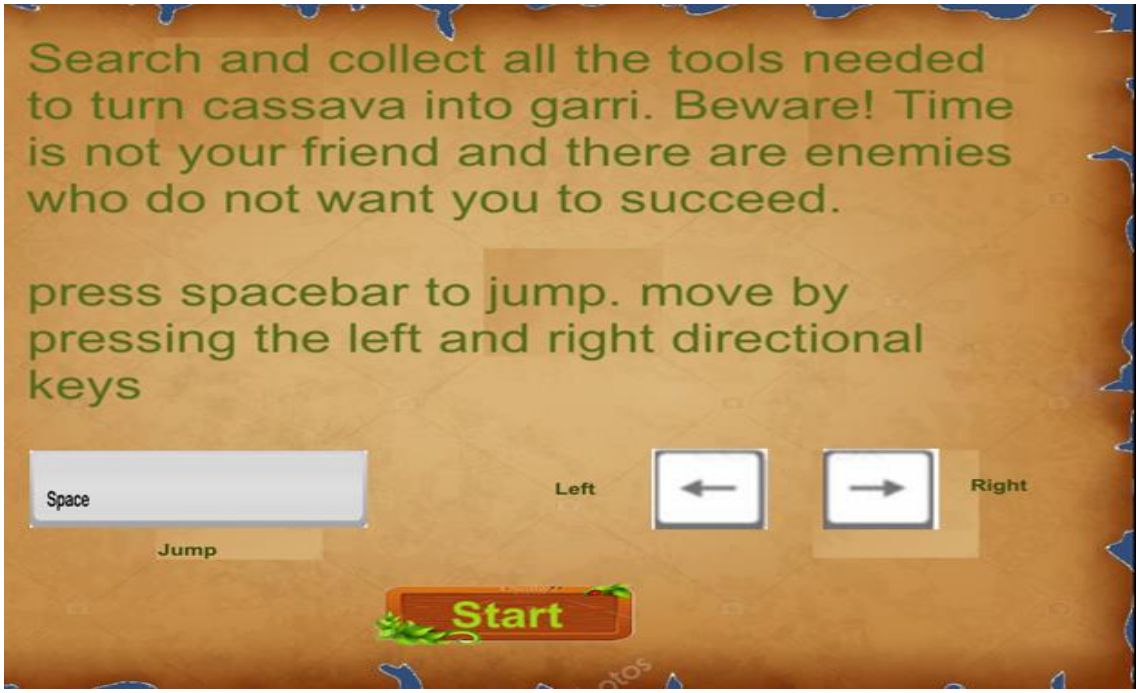

Figure 26: Panel showing rules and instructions on how to play scene 2

Figure 27: cross section of scene 2 in game play mode part 1

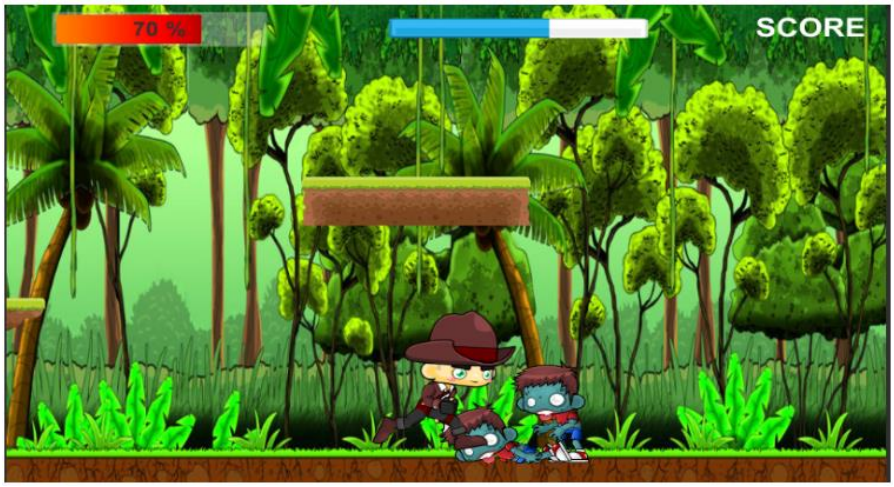

Figure 28: cross section of scene 2 in game play mode part 2

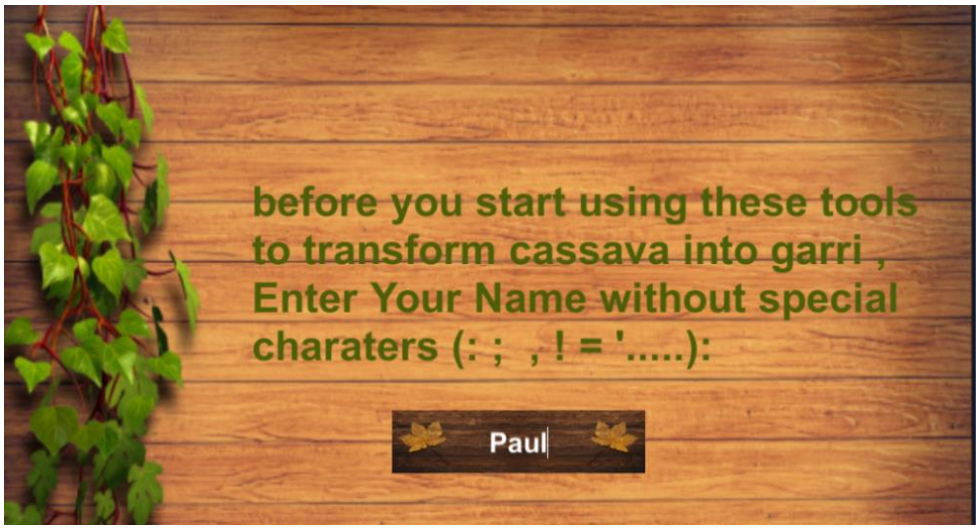

Figure 29: screen shoot showing enter name panel

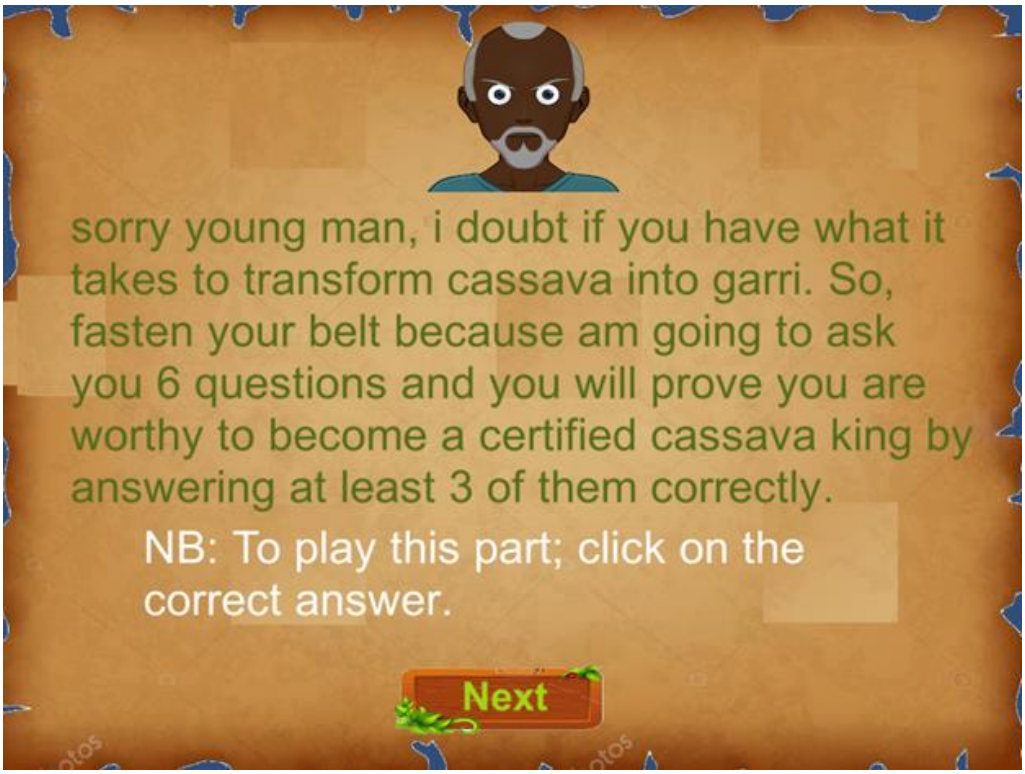

Figure 30: screen shoot showing rules and instructions of scene 3

Figure 31: Scene 3 in game play mode

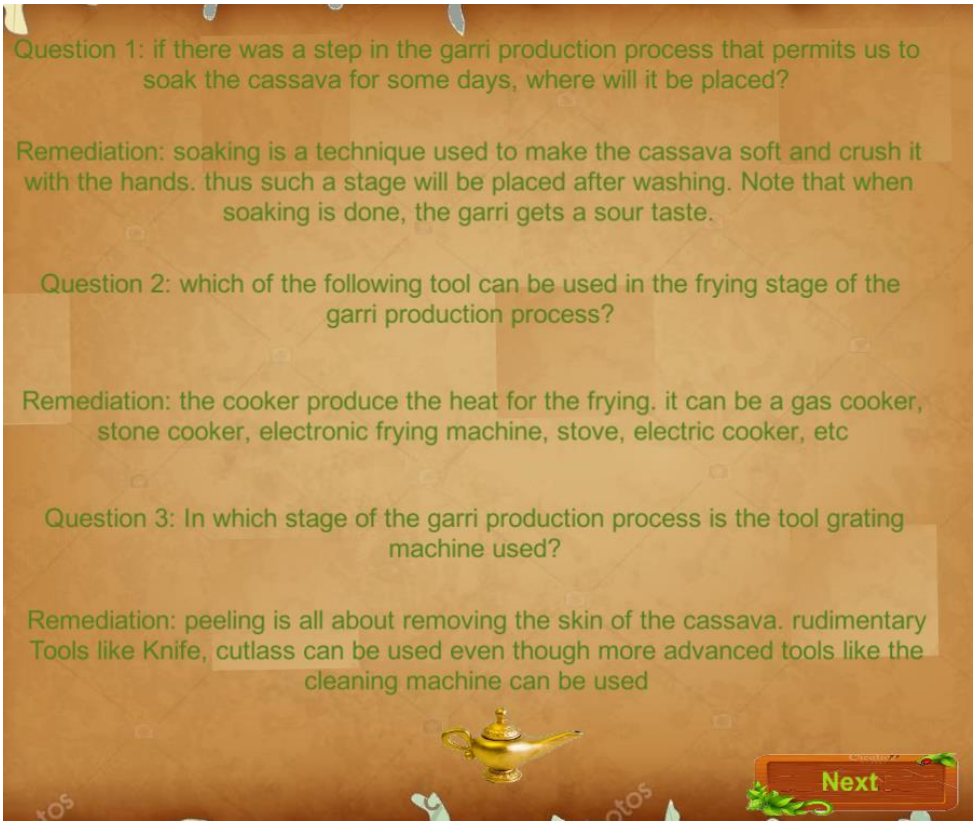

Figure 32: game play mode showing remediation at the end of scene 3

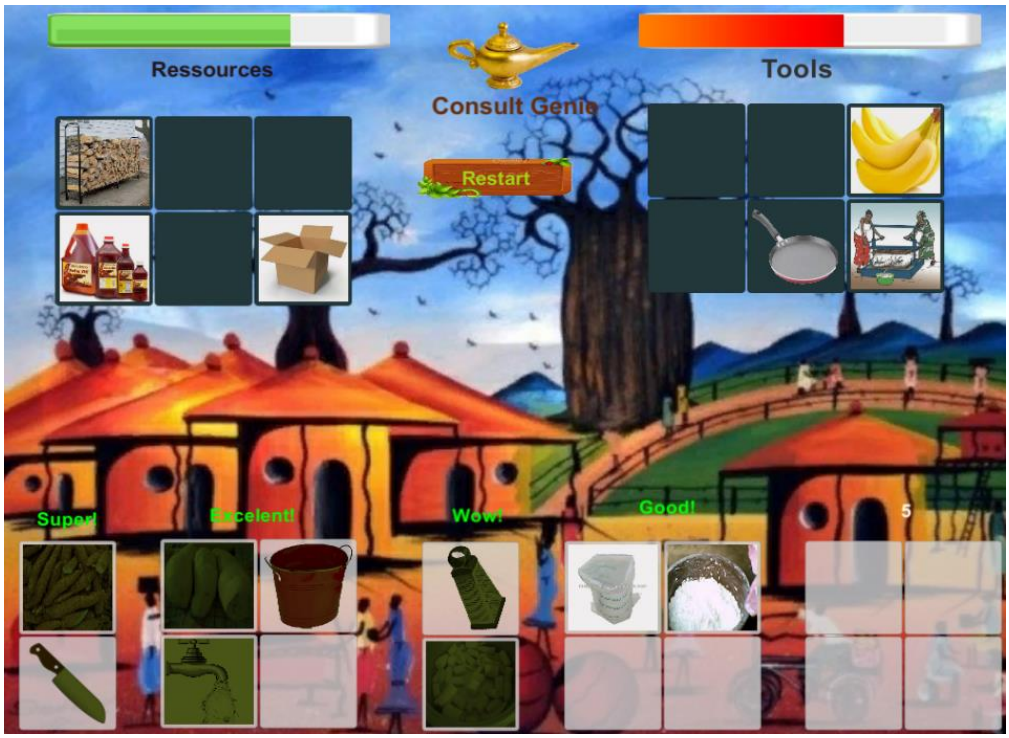

Figure 33: screen shot of scene 4 in game play mode

Figure 34: screen shot of game over panel

Figure 35: screen shot of leaderboard

Figure 36: screen shot showing the different menus in view content

4.4.

4.3.3. Producing documentations

The different documentations that complement this product can be accessed via appendix F of this dissertation.

4.4. Test and Evaluation

During this phase, we performed a beta test, a pilot, and evaluated the student reaction and learning after the pilot lesson.

4.4.

4.4. 4.4.1. Alpha test

The questions built to capture the reaction of our alpha test audience were asked after presenting the tutorial. Pertinent responses and comments are shown in table 4.3 below.

4.4.

Table 4.3: table showing responses to questions asked to the audience of the alpha test and important comments made

4.4.

Questions	answer	comments
Is the language level conducive?	yes	
Are the writings visible and clear?	No	The colors used do not go together
Is the screen size used appropriate?	yes	The tutorial is not responsive
Are reviews and summaries adequate?	yes	
Are Transitions comfortable?	Yes	The story structure implemented it, but since it is in text form and students do not like reading, they will find it boring
Is feedback to trainee sufficient?	No	Remediation should be added for scene 3
Is content relevant to trainee?	Yes	
Is the sequence logical?	Yes	
Is overview adequate?	Yes	
Is the pace adequate?	No	Time on lesson plan not realistic
Are directives to learners clear and complete?	No	Add directives in story and show directions of movement with arrows.
Is the amount of material appropriate for the time?	No	If specific videos are targeted, material may be enough.
Is task analysis sufficient?	Yes	
Are the menus available as needed?	No	Absence of opportunity to get help when playing.
Are objectives clear and complete?	yes	
Are all terms properly defined?	yes	
Is important content properly stressed?	yes	Subtle repetition is used to emphasize important content.
Are evaluations sufficient	yes	
Are objectives met	yes	
Can the activities keep trainee's interest?	yes	

The main advice received from the members of the audience was focused on the user interface of the tool. The instructional designers of the group pointed out that the amount of time chosen was not realistic for someone playing the game for the first time. They advised we use a 35-40 minutes to present the first transformation, and after that we can even perform 3 different cassava transformations in 50 minutes.

The result of the usability with respect to the evaluation grid given to the teachers is presented in table 4.4 below.

Table 4.4: score allotted to cassava king for each ergonomic criteria

Criteria	Sub criteria	Score/5	Comments
Guidance	Prompting	4	
	Grouping / Distinction of items	4	
	Immediate feedback	5	
	legibility	5	
Workload	Brevity	3	,
	Information density	3	
Explicit control	Explicit user action	5	
	User control	3	
Adaptability	flexibility	2	
	User experience	3	
Error Management	Error protection	4	
	Quality of error messages	3	
	Error correction	3	
consistency	consistency	4	
Significance of code	Significance of code	3	
Compatibility	compatibility	3	

Table 4.4 shows that the average score for each criterion was either average or above average. The overall usability test shows that the tutorial cassava king is usable; since we computed the average usability score and had a value that can be rounded up to 4 which means good according to our scale.

Nevertheless, the following comments were received from the usability testers. Firstly, they claimed there was too much text and reading to be done by the learner. Then, they commented on the fact that the player has little or no control on the positioning of the user interface. They advised I give names to icons that are easy to understand. They also commented on the graphics used and proposed I look for a graphic engineer to help produce more attractive graphics.

Efforts were made to integrate the advice of the experts involved during the alpha test.

4.4.2. Beta test

The main aim of the beta test was to measure the effectiveness of the tutorial. To make sure the implementation for the experimental group ran smoothly, we first of all took some time before the schedule test to see if the tutorial will run well in the training environment (laboratory). There we discovered some issues like the graphic card of some machines unable to support the tutorial, most machines not having drivers for sound, and cascading sounds if headsets are not used.

To overcome these issues we decided to change the lesson plan and didactic materials. The plan was to use loud speakers and a projector, then make the students follow all the demonstrative videos and 3 presentation videos. The students where then asked to complete the different scenes in the game. The tutorial was thus used more like a tool to evaluate learning.

The respective feedbacks gotten after running the pilot are shown on the Table 4.5 below.

Table 4.5: table showing the feedbacks of the pilot implementation

Section studied	comments
Logistics of delivery environment	All computers were operational; there was no power shutdown; the standby generator was in good state, the environment was conducive for TBT; the tool could not install on 22% of the machines because of the absence of graphic drivers. Also, most of the machines did not have sound drivers.
Effectiveness of lesson plan and content	The main issue with the lesson plan was that the estimated time for the lesson was not enough. The lesson took more time than planned.
Student attitude	The students were eager to learn and enjoyed the time each video took. The students claimed the game was intuitive but not fun.
General	All 22 students affirmed they preferred videos that had a practical demonstration on how to do it than videos that just presented how to do it. The length of the videos was highly appreciated by the students.

We recommend that before a user installs this tool, they should first of all read the installation notes and verify if their machines fit the system requirements for this tutorial. We advise sound drivers should be installed in computers and that headsets be placed on each machine in the delivery environment if we expect students to make the most of the tutorial. Generic graphic drivers should be installed in the machines and we should purchase machines which have a good video memory.

4.4.3. Evaluating Student Reaction

From the reaction sheet filled by the 22 students in the experimental group, 18 claimed that they mastered the course objectives while 4 of them were neutral. Some 18 students agreed that the text content was too much while all the students preferred demonstration videos over presentation videos. A detailed feedback from the students is provided in the Table 4.6 that shows the frequency per question per scale value.

Table 4.6: cross table showing student reaction after implementation

Questions	scale		
	1	**2**	**3**
I was able to master the course objectives	0	4	18
We had time to complete all the course material properly	4	2	16
The video or text content was very useful to complete the game	0	0	22
The text content was too much	18	2	2
The video content was too long	18	4	0
Videos that showed what was happening were better than the other videos	0	2	20
The story of the game was very captivating	10	8	4
I will love to play the game again and see new challenges	13	3	6
I did not like the images used.	8	9	5
The lesson was easy for me to understand	0	3	19

From table 4.1 we also notice that you cannot complete a level of the game if you do not master the concepts that are presented in the videos. We further see that students prefer seeing how something is done than just hearing it. We do also observe that most of the students did not find the story of the game captivating; which implies we have to reflect on how to make the game more interesting.

The overall feedback was that the tool cassava king made the lesson easy to understand than a traditional lesson and that students preferred it over a traditional lesson.

4.4.4. Evaluating Learning

During implementation, a hand written evaluation was performed for the 22 students in our control group and the 22 students in our experimental group. 19 of the students in the experimental group passed the test compared to 14 students in the control group. Also, results of the students that failed in the experimental group showed that they could remember the steps used in transforming cassava in to "garri" and the tools needed for each step. They failed because they did not connect these steps to the context given in the exercise.

These results helped us conclude that the tutorial did not only enhance learning on the transformation of cassava into garri, but also improved retention of the concepts learnt which is no surprise when we consider Edgar Dale's cone of learning (1969), since the students in the experimental group did not only hear what was to be done, but also saw and simulated it. This according to E. Dale breeds a 90% retention capacity.

Chapter 5: Effects of project on educational system, Conclusion and perspectives

5.1. Effects of project on educational system

One of the goals of a 21st century Cameroon is to inculcate the digital culture in its citizens. Cassava king will help cement the use of ICT tools and thus reinforce the digital culture.

Another goal of a 21st century Cameroon is to provide its future generation with indispensible 21st century skills like critical thinking, problem solving, creativity etc. These skills are naturally promoted by integrating gamification into the teaching-learning process. Cassava king will help young Cameroonians develop these highly demanded skills for a 21st century Cameroon.

Also, Cassava King will help provide highlights on the necessity of integrating gamification and micro-learning into difficult lessons like Geography, Mathematics, Physics, and Literature. Moreover, lessons that are impractical or costly to experiment can be simulated with the help of Game based management systems. Cassava King will help show that such simulations can provide acceptable results for learners. It can also be used as content provider, evaluator, and scaffold for learning how to transform cassava into "garri" or "bobolo".

Cassava king will not only provide a possibility for students to practice and retain how to transform cassava into its end-products, but can also be extended to teach other concepts like resource management, entrepreneurship, responsible health behaviors during manufacturing, and more. Like other tools already developed in the Cameroonian context, this tool will provide the:

- Possibility to be used in school and at home
- Possibility for students to get use to technological pedagogic resources
- Possibility for teachers to use blended approaches of teaching that is more effective than traditional teaching.

Unfortunately in a context where Cameroon is focusing on socio-cultural diversity, this project for now has an influence only in the Anglophone subsystem since content of the tutorial is in English. Also, cassava king being a one player game does not also promote social interaction and teamwork.

5.2. Conclusion and Perspectives

Educational technologies bring a student centered approach to the teaching-learning process and also ignite student curiosity. Using elements of game mechanics and game thinking guarantee attention, engagement, and retention. Micro-learning reduces cognitive stress and makes learning specific and short. All these concepts and others were integrated into the instructional game

“cassava king” whose goal is to facilitate learning of the lesson on the transformation of cassava into its end-products.

The observations via the reaction sheet proved that “cassava king” ignited curiosity, attention, and engagement. The evaluation revealed that even students who failed the end of lesson test still remembered the content of the lesson which implies retention was attained. The students failed because they could not put the knowledge in context which implies transfer is still a problem. But having 86% of the students passing the test implies a considerable amount of students could transfer the learning.

These results was no news to us since most educators had discussed elements that if found in abundance in a learning situation will maximize learning. Table 5.1 shows some of these elements and how each approach to teaching contributes in promoting it (the greater the asterisk, the more the approach contributes to the element).

Table 5.1: Table showing the degree to which each approach to teaching contributes to elements indispensible for effective learning

	Traditional approach	e-learning approach without gamification	e-learning approach with gamification
motivation	*	**	***
engagement	*	**	***
attention	*	**	***
Interactivity	*	**	***
Continuous practice	**	**	***
No fear of failure	*	**	***
play	*	*	***
story	*	*	***

From the table, we notice that most educators think that games in education promotes motivation, engagement, attention, interactivity, continuous practice, no fear of failure, play and story which are elements that help provide effective learning. Cassava King being an educational game also enjoys these benefits. This implies that, students of the experimental group could retain what they learnt because all these elements were highly present during the lesson.

Educators also advocate that game based learning supports 21st century skills. Below is a table showing different approaches to teaching and the rate at which they support 21st century skills (the greater the asterisk, the more the approach supports a skill).

Table 5.2: illustration of how respective teaching approaches support 21st century skills

	Traditional approach	e-learning approach without gamification	e-learning approach with gamification
Problem solving	**	**	***
Changing attitudes	**	**	***
Interpersonal skills	**	*	*
creativity	*	**	***
Critical thinking	*	*	**
Technology literacy	*	**	**
Team work	**	**	**

From this table, we notice that game based learning highly supports acquisition of 21st century skills which are the solution to a changing job market. Even though Cassava King does not support team work for now since it is a one player game, it stills supports the other 21st century skills which makes it a tool that can help create a 21st century Cameroon.

The game takes at most 24 minutes in the worst case scenario to follow content and complete challenges compared to a real life practical lesson that may take up to 8 hours in the worst case scenario and 3 hours in the best case scenario. With this in mind, we can see that cassava king does not only reduce the cost intensive nature of putting into practice such a lesson, but also reduces the time needed to learn and practice this lesson.

We are certain that if a student follows a particular transformation 3 times using cassava king, he will be able to transfer the retained knowledge. The elements of change integrated in the game will not only facilitate the replay of the game without the student getting bored, but will also facilitate transfer since student will be challenged with a variety of real life situations.

Even though Cassava King highly supports effective learning, it still needs some enhancements. The web version of cassava king does not have a means for the learner to get help by watching videos. The desktop version is not responsive, and there is no mobile version. Also, other end-products of cassava like starch, "water fufu", etc. are not yet part of the tutorial. Moreover, most students claimed the game was not fun enough; one of the ways we will address this is to keep on getting feedback from the students and ameliorating the fun part while keeping the objectives in check. Another way will be to integrate the learning objectives to already proven fun games like zuma, candy crush, etc. Furthermore, other elements like using the game "cassava king" to teach resource management, responsible health behavior when manufacturing can also be added; and such addition will guarantee the understanding of transforming cassava into its end-products since it will be a prerequisite for the resource management or responsible health behavior training.

Although the results obtained after evaluating the experimental group was no surprise, we still think the results gotten during the beta test may be influenced by confounders like the fact that

the biology test the students failed during normal school session did not come immediately after the lesson like the evaluation that was done during the beta test. Moreover, the amount of material tested during the session of putting the system into use was relatively very small compared to the amount of material tested during the respective sequential test. Which brings up questions like: for how long can the student retain knowledge after playing cassava king? Will the student score the same if the test was on the whole chapter on animal and plant transformation?

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Appendix A: Check list to identify when to use TBT

Use TBT when:

- ☐ Self-instruction is needed (see self-instruction checklist)
- ☐ Complex simulations are needed
- ☐ The content requires a lot of practice that can be simulated
- ☐ The trainees are comfortable or can be made to feel comfortable using computers
- ☐ Training is difficult to schedule or classes are hard to fill
- ☐ There is plenty of development time and money available
- ☐ The hardware is in place or can be bought easily
- ☐ Tracking of the training is critical and time intensive due to a large number of trainees
- ☐ Management is comfortable with TBT or can be sold on the concept
- ☐ Updates to the program will be minimal
- ☐ The use of multiple media formats will enhance the learning

Figure 37: checklist to help know when to use TBT

Cited in George M. Piskurich 2006, p96

Appendix B: instruments used during analysis

Questionnaire for Form 5 students

Aim: know student learning preferences and difficulties in learning cassava transformation into by-products

My names are Nfor Ngala Nelson, student in the department of Computer Science of HTTC Yaounde. As my final year research, we intend to know the problem faced by Form 5 students in studying biology in general and specifically the lesson on transformation of cassava into its by-products. We wish each and every one of you to genuinely contribute by answering the questions below, so that we can use it to produce learning resources that take into consideration your individual ways of learning.

Instructions: tick the box you agree with or fill in the blank spaces.

Enter your age here ____ Enter your gender here ____

1. On a scale of 1 to 5, 5 being very good, rate each of the methods that can be used to present learning content?

method	1	2	3	4	5
Reading textual content					
Watching a video					
Listening to an audio					
Playing a game					
Representing content as images					
real life representation of lesson					
Discussion with others					

2. On a scale of 1 to 5, 5 being very good, rate each of the methods that can be used to present a lesson on how to transform cassava into garri.

method	1	2	3	4	5
Reading how to do it					
Watching video on how to do it					
Listening on how to do it					
Playing a game on how to do it					
Showing images on how to do it					
Physically participating on how to do it					
Discussion with others on how to do it					

3. Do you think a lesson that teaches you how to transform cassava into garri will be difficult?
   Yes ☐ No ☐
4. Give reasons for your answer in question 3 above

_____

_____

_____

5. On a scale of 1 to 5, with 5 being very high, rate the degree at which each obstacle below can play to hinder your understanding in the lesson on the transformation of cassava in garri.

obstacle	1	2	3	4	5
No opportunity to experiment and practice in real life					
Teacher does not explain well					
Unable to focus on the lesson for more than 5 minutes					
Too much notes to copy					

6. Give other obstacles if any.

_____

_____

7. Do you have a computer?
   Yes ☐ No ☐ No, but there is a computer at home that I can use ☐
8. What do you use the computer to do?
   Play ☐ watch videos ☐ read ☐ communicate ☐
9. Do you have a smart phone?
   Yes ☐ No, but I have a phone ☐ No ☐
10. What do you use your phone for?
    Play ☐ watch videos ☐ read ☐ communicate ☐ search for information on the internet ☐

Figure 38: questionnaire used to collect data from students

Questionnaire for Biology teachers

Aim: know the difficulties of teaching biotechnology; more precisely, the lesson on transformation of cassava into its by-products.

Dear Colleague, it is with honor and respect that I am asking for your assistance. My names are Nfor Ngala Nelson, student in the department of Computer Science of HTTC Yaounde. As my final year research, we intend to know the difficulties faced by biology teachers when teaching biotechnology in general; more precisely, the transformation of cassava into its by-products.

Our objective is to build technological resources that can mitigate some of these difficulties and foster student understanding. We wish in advance, to thank you for your sincere cooperation.

Instructions: tick the box you agree with or fill in the blank spaces.

1. On a scale of 1 to 5, with 5 being very high, rate the degree at which each obstacle below can play to hinder the lesson on the transformation of cassava into its by-products.

obstacle	1	2	3	4	5
No opportunity for students experiment and practice					
Impractical nature of experimenting such a lesson					
Too risky since some resources needed can be harmful					
Low motivation of students to learn such lessons					

2. Give other obstacles if any.

_____
_____
_____
_____

3. Which teaching method will you use to teach the transformation of cassava into its by-products?

_____
_____
_____

4. What can be the objectives of the lesson on transformation of cassava into its by-products?

_____
_____
_____
_____

5. If you were precisely teach the transformation of cassava into garri, how will you break down the lesson? (E.g. I will have a section for the tools, another section for the steps to transform, etc.)

_____
_____
_____
_____
_____

6. Do you have a computer? Yes ☐ No ☐
How will you classify your computer literacy skills? Very weak ☐ Weak ☐ Average ☐ Good ☐
7. Given a pedagogic resource, will you like to have control over its content (e.g. changing the content, changing the exercises, changing the problem situation, etc). Yes ☐ No ☐
8. Do you think a learning software can help facilitate the cassava to by-products lesson?
Yes ☐ No ☐
9. What functions do you think such learning software should have?

_____
_____
_____

10. Do you have any advice for me or the HTTC Yaounde?

_____
_____

Figure 39: questionnaire used to collect data from teachers

Task Analysis Form

Task or Subtask: _____

Date: _____

Element	Description
Inputs	
Steps	
Tools	
Standards	
Circumstances	
Outputs	
KSAs	

Figure 40: Task Analysis Form

Cited in George M. Piskurich 2006, p444

Appendix C: Alpha test aids

RUNNING A BETA TEST

1. Explain what the participants will be doing and why they are here.
2. Describe how their feedback will be used.
3. Discuss the confidentiality of their feedback.
4. Audiotape if possible, but ask permission.
5. Keep track of time for first finished, last finished, and an average.
6. Don't forget breaks.
7. Ask the stakeholder to attend at least the debriefing.
8. Be sure to follow your evaluation criteria in the debriefing.
9. Give yourself enough time to gather all opinions and to write a good report.

Figure 41: Framework for running a beta test which we will use for our alpha test Cited in George M. Piskurich (2006, p241)

Alpha test interview form

1. Tick "Yes" or "No" if you agree with each questions that follows

Question	Yes	No
Is the language level conducive for the learners?		
Are the writings visible and clear enough?		
Is the screen size appropriate?		
Are reviews and summaries adequate?		
Are Transitions comfortable?		
Is feedback to trainee sufficient?		
Is the content relevant to trainee's situation?		
Is the sequence logical		
Is overview adequate?		
Is the pace adequate?		
Are directions to learners clear and complete?		
Is the amount of material appropriate for the time?		
Is task analysis sufficient?		
Are the menus available as needed?		
Are objectives clear and complete?		
Are all terms properly defined?		
Is important content properly emphasized on?		
Are evaluations sufficient?		
Are objectives met?		
Can the activities keep trainee's interest?		

2. Is there any question I did not consider that you think is necessary?

_____

_____

3. Is there any advice or comment you have for me?

_____

_____

Figure 42: Alpha test interview questions

Evaluation grid based on Bastien & Scapin usability criteria for usability testers during alpha testing

1 = very low 2 = low 3 = average 4 = good 5 = very good

Criteria	Sub criteria	score	Comments
Guidance	Prompting		
	Grouping / Distinction of items		
	Immediate feedback		
	legibility		
Workload	Brevity		,
	Information density		
Explicit control	Explicit user action		
	User control		
Adaptability	flexibility		
	User experience		
Error Management	Error protection		
	Quality of error messages		
	Error correction		
consistency	consistency		
Significance of code	Significance of code		
Compatibility	compatibility		

Figure 43: Evaluation grid for usability test

Appendix D: Beta test aids

Beta test questions: to be filled by instructional designer

1. **Logistics of delivery environment**

Question	Yes	No
How many computers crashed during the training?		
Was there any power shutdown?		
Is the standby generator operational?		
Was there any complain about the components of the computers?		
Is the environment conducive for learning?		
Can the tutorial be installed on the machines of the laboratory?		

2. **Effectiveness of lesson plan and content**

Question	Yes	No
Were the activities easy to understand?		
Did the activities take much time than planned?		
Was there any prerequisite we did not capture?		
Were the students bored during the training?		
Was the lesson in time, on time or out of time?		
Was the participation adequate?		
Was the pace adequate?		
Were the videos easy to understand?		
Did all navigation points work as specified?		

3. **Learner's attitude**

Question	Yes	No
Were the learners bored?		
Did they intuitively know what to do?		

Was the game fun? Why?

_____

_____

What advice can you give to make the game more fun?

_____

_____

Was the game difficult to play? Why?

_____

_____

4. **General**
   - ✓ Which difficulties did you face during this lesson?
   - ✓ What changes do you think can be made on this game?

Figure 44: Beta test questions

Appendix E: Testing and Evaluation aids

Reaction sheet for students to fill a lesson with the tutorial

Use the scale below to indicate your opinion on each of the following statements

3 = agree, 2 = neutral, 1 = disagree

Questions	scale		
	1	2	3
I was able to master the course objectives			
We had time to complete all the course material properly			
The video or text content was very useful to complete the game			
The text content was too much			
The video content was too long			
Videos that showed what was happening were better than the other videos			
The story of the game was very captivating			
I will love to play the game again and see new challenges			
I did not like the images used.			
The course was easy for me to understand			

Figure 45: Reaction sheet to fill after playing or exploring "cassava king"

Formative Evaluation after lesson with "Cassava king"

1. Which was the mark range for your previous biology test? Tick four times for each sequence (1st and 2nd, 3rd and 4th sequence).

Mark range	0-3	4-6	7-9	10-12	13-15	16-18	19-20

2. Imagine you are in an environment having the following objects: a short machete, tubers of cassava, a blender, a spring, a bowl, a clean piece of cloth, frying pan, and a gas cooker. Assuming there is electricity, and gas, Use the above information to answer the following questions:
   a) Explain how you will achieve each step of garri transformation? (5mks)
   b) Deduce the type of garri that can be produced here? Explain your answer (1mk)
   c) Determine 2 advantages and 2 disadvantages of your transformation process described in 1 above? (4mks)

Figure 46: Questions used to evaluate learning after lesson using "Cassava king"

Table Appendix E: Test performed per phase in the GADDES life cycle

phase	Tests performed	description
Analysis	Acceptance testing	✓ Meeting with end users to confirm the requirements detected are what they expected.
Design	Testing objectives and outline	✓ Verifying if objectives are SMART. ✓ Verifying if outline respect best practices of micro-learning. ✓ Meeting with biology teachers to validate objectives.
	Testing the game script	✓ Verify the presence of elements of game thinking and game mechanics ✓ Verify if best practices for implementing gamification are present ✓ Verify if game script meets the objectives of the lesson ✓ Verify if game script respect best practices of micro-learning
	Unit, integration, and system test for respective user stories	✓ Verify if class diagrams effectively solve the specific problems they are to solve. ✓ Verify if the global class diagram solves the main problem (meet customer's expectation) ✓ Verify if best practices of object oriented design are applied (flexibility and reusability test)
	Testing documentations	✓ Verify if different parts of the documentation are conforming to standard documentations.
Development	Test learning content	✓ Verify if content meets the objectives of the lesson ✓ Verify if content respect best practices of micro-learning
	Testing the documentations	✓ Verify if different parts of the documentation fit the tool ✓ Verify if core parts of the documentations have content
	Testing the source code (unit test, integration test, system test).	✓ Verify if each method does what it is supposed to do ✓ Verify methods work together. ✓ Test the whole system for defects.
	Test & Evaluation (alpha test, beta test, evaluating student reaction, evaluating learning)	✓ Test usability of the whole system ✓ Deploy system to see if deployment environment meets system requirements ✓ Get feedback from users on how to ameliorate the tutorial ✓ Verify if tutorial enhances learning

Appendix F: Link to other resources

Resource	link
Game script	https://docs.google.com/document/d/1NlJVUxL13x6vvO2xBd16uBUL_kdPS1hbYy-4wD0Tgys/edit?usp=sharing
Students' guide	https://docs.google.com/document/d/1c3tXClrVcMB7B_wuDZM5Pr-O9_8jx9ipyfoDGYzrVdY/edit?usp=sharing
Teachers' guide	https://docs.google.com/document/d/1tjvn2dF_V5pb4x5jQTTvxPIBehDTzeEhtAf5vPCAO2M/edit?usp=sharing
Developers' guide	https://docs.google.com/document/d/16pujlMW_uXQ9kLMLWfQALT1NldjtDgJbBl90ZN-pe58/edit?usp=sharing
Instructional designers' guide	https://docs.google.com/document/d/1TVG-n_QNe1CFKAEIGh6WGzvGKTOpycCq7AM_MVPz018/edit?usp=sharing