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Effects of Climate and Land Use Change on Food Security: a Case Study of Phra Nakhon Si Ayutthaya Province, Thailand

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Abstract

Addressing climate change for food security poses a great challenge to social welfare in developing countries where agricultural sector plays a significant role in driving economic growth and sustaining livelihoods. Natural climate variability and anthropogenic emissions introduce the considerable effects on agriculture yields and productivity, including nexus of food-water-energy. This paper aims at exploring land suitability for rice farmland in Phra NaKhon Si Ayuttaya province. Projection of temperature and precipitation over a province in 2050 in according to representative concentration pathway (RCP) 4.5 and 8.5 scenarios show a few increase in mean monthly temperature, monthly maximum temperature and minimum temperature about 0.5 to 1 degree celcius. Annual precipitation tends to be reduced for RCP 8.5 in comparison to RCP 4.5. Land suitability for growing rice is simulated by using EcoCrop model which requires input parameters from temperature and precipitation projection in 2050. Results reveal a decreasing in land suitability for rice both under RCP 4.5 and 8.5 scenarios. Agricultural land use tends to be transformed into residential and industrial land by 2050, resulting in the reduction in agricultural land and rice production. Successful adaptation to climate change in the agricultural sector needs to be encouraged by government to build robust cooperative efforts from all stakeholders.

Keywords: Climate change; rice; Phra Nakhon Si Ayuttaya, food security; adaptation

Introduction

Addressing climate change for food security poses a great challenge to social welfare in developing countries. Climate change, population growth and land use transition are among drivers contributing to food insecurity, water scarcity and ecosystem degradation. Extreme weather such as flood, drought and storm driven by climate change are expected to gradually increase and will deliver huge effects on food production and water availability. Meanwhile, climate variability can capable of

influencing year to year crop production, even in high yielding and high-technology agricultural areas (Kang et al., 2009). It is expected that about 70 percent of water withdrawal from irrigation system will be used in crop production. There are reports suggesting that weather change could reduce grain yields of rice and wheat in Indo-Gangetic Plains (IGP) (Aggarwal et al., 2004). Beside the direct impact of climate change on crop yields, there are some evidences related to indirect impacts caused by climate change in changing soil moisture and spatial distribution of pest (Mendelsohn, 2014)

Nowadays, climate change and global food crisis receive considerable attention, especially in Africa and Asia. Adaptation study conducted by Calzadilla et al. (2014) suggested that Africa would require yield improvement of more than 20 percent over baseline investment in agricultural research and development and an attempt to irrigation development will no longer be sufficient for agriculture. Research conducted by Naresh Kumar et al. (2013) shown a decrease in irrigated rice yields in India by about 4, 7, and 10 % during the 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099), respectively.

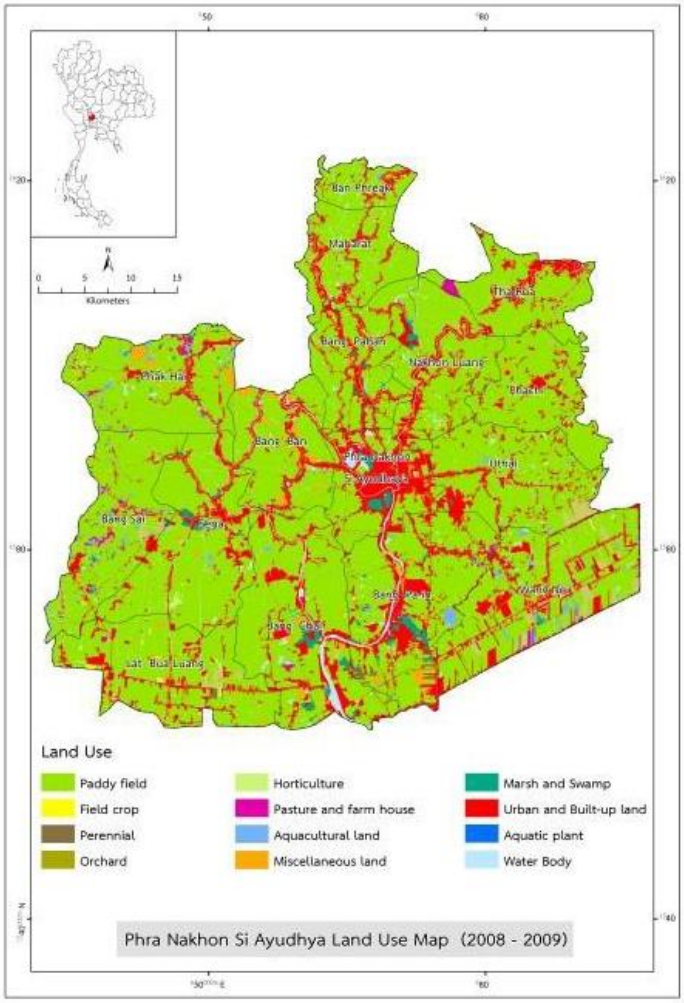
Phra Nakhon Si Ayuttaya is one of the central provinces of Thailand where it is famous for history, culture, rice farmland, industry and tourism. Most of agricultural land in the past is typically devoted to rice cultivation. However, area of rice cultivation tends to be decreased by 14.77 % from 2008 to 2013. In the last two decades, the province has also been suffered from water related disaster more frequent than the past. A great flood of 2011 in Thailand witnessed its worst flooding in Thailand and caused significant loss and damage to agricultural are in Phra Nakhon Si Ayuttaya province, including rice cultivated area.

Method

Mean monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature and annual precipitation in 2050 are extracted by using WorldClim database (www.worldclim.org). HadGEM2-ES climate model is used for generating climate database for representative concentration pathway (RCP) 4.5 and 8.5. In order to analyze land suitability for rice under eleven climate factors; *Tkill* (temperature at which the crop will die in celsius), *Tmin* (minimum temperature at which the crop will grow in celsius), *Topmin* (minimum optimum temperature at which the crop grows in celsius), *Topmax* (maximum optimum temperature at which the crop grows in celsius), *Tmax* (maximum temperature at which the crop will grow in celsius), *Rmin* (minimum amount of rain water required for the crop to grow in mm), *Ropmin* (minimum optimum amount of rain water required for the crop to grow in mm), *Ropmax* (maximum optimum amount of water for the crop to grow in mm), *Rmax* (maximum amount of rain water below which the crop grows in mm), *Gmin* (minimum length of the growing season in days),

and *Gmax* (maximum length of the growing season in days) are created by Ecocrop model. Land suitability for rice is illustrated by six suitability classes.

From the past land use change, area of rice farmland in Phra Nakhon Si Ayuttaya has been decreased by 14.77 percent between 2008-2013 as shown in Figure 1. Rapid urban land expansion is a main reason behind transforming from agriculture to urban land. In response to urban sprawl, adaptation practices are analyzed by comprehensively reviewing previous literatures and related government policy related to agricultural sector. It is expected that agricultural land use will be transformed to residential and industrial area in 2050 which entails a significant change in surface runoff and population. A proposed plan for adaptation to climate and land use change in agriculture, focusing on rice farmland, is developed in accordance with food security and farmer well-being perspectives.



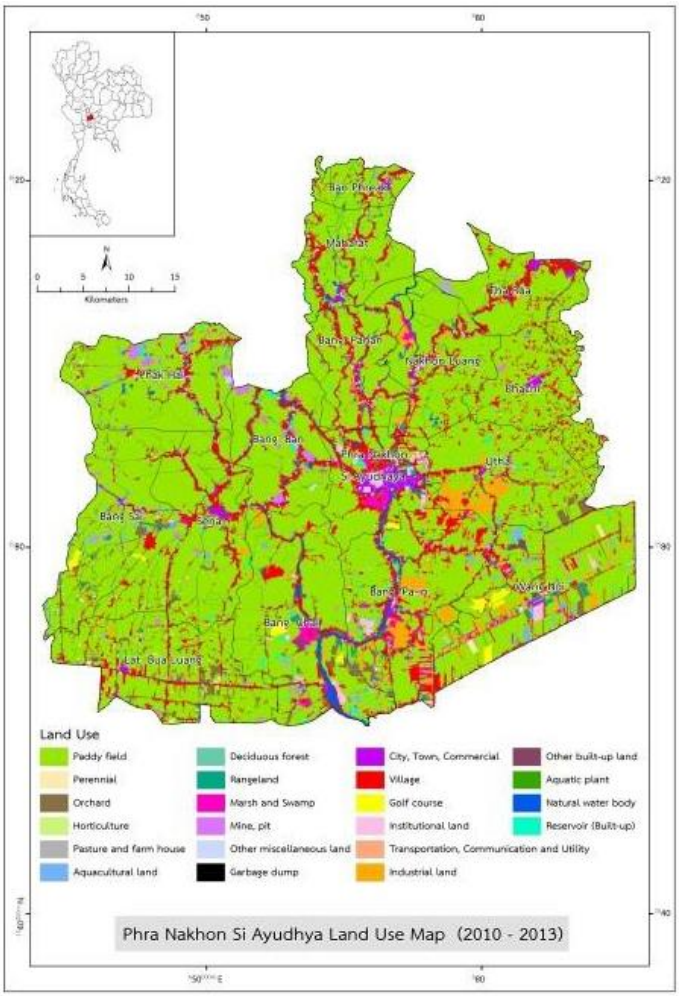


Figure 1 Land use change between 2008-2013 in Phra Nakhon Si Ayuttaya province

Results and discussions

Mean monthly average temperature is within the range of 30 °C to 31 °C by 2050 for RCP 4.5 and tends to increase about 0.5 °C under RCP 8.5. The increase in mean monthly average temperature for RCP 8.5 is equally distributed in every district in a province as shown in Figure 2

The highest mean monthly minimum temperature occurred in Bang Sai, Bang Pa-in and Wang Noi districts for RCP 4.5 and RCP 8.5. Changing in mean monthly minimum temperature is expected to be increased by 0.5-1.0 °C as shown in Figure 4. Mean monthly maximum temperature varies from 35 °C to 35.5 °C for RCP 4.5 and tends to be increased by the range of 35.5 °C to 36.5 °C for RCP 8.5. The highest temperature

found in Ban Phreak and Maharat districts for RCP 8.5 as shown in Figure 3. According to annual precipitation in Figure 5, amount varies from 1,200 mm to 1,391 mm and 1,120 to 1,288 for RCP 4.5 and RCP 8.5 respectively. Wang Noi and some area of Uthai districts appear to be highest temperature for RCP 8.5.

Mean monthly average temperature

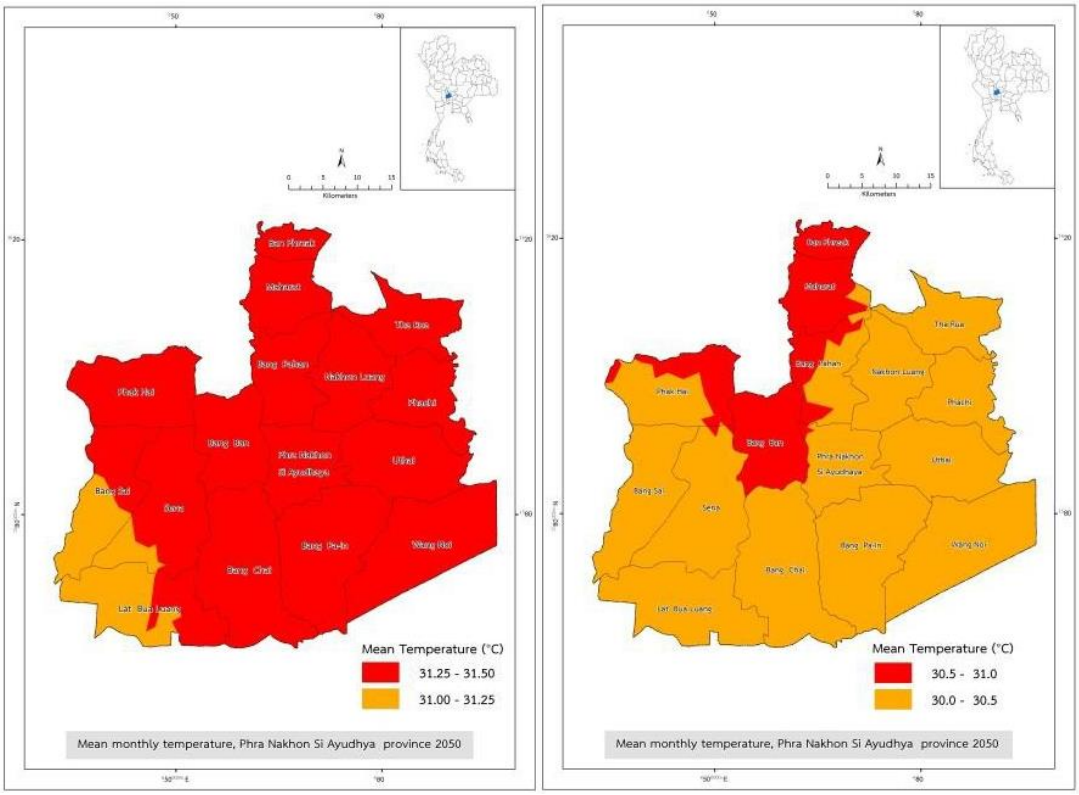


Figure 2 Mean monthly average temperature for RCP 4.5 and 8.5 in 2050

Mean monthly maximum temperature

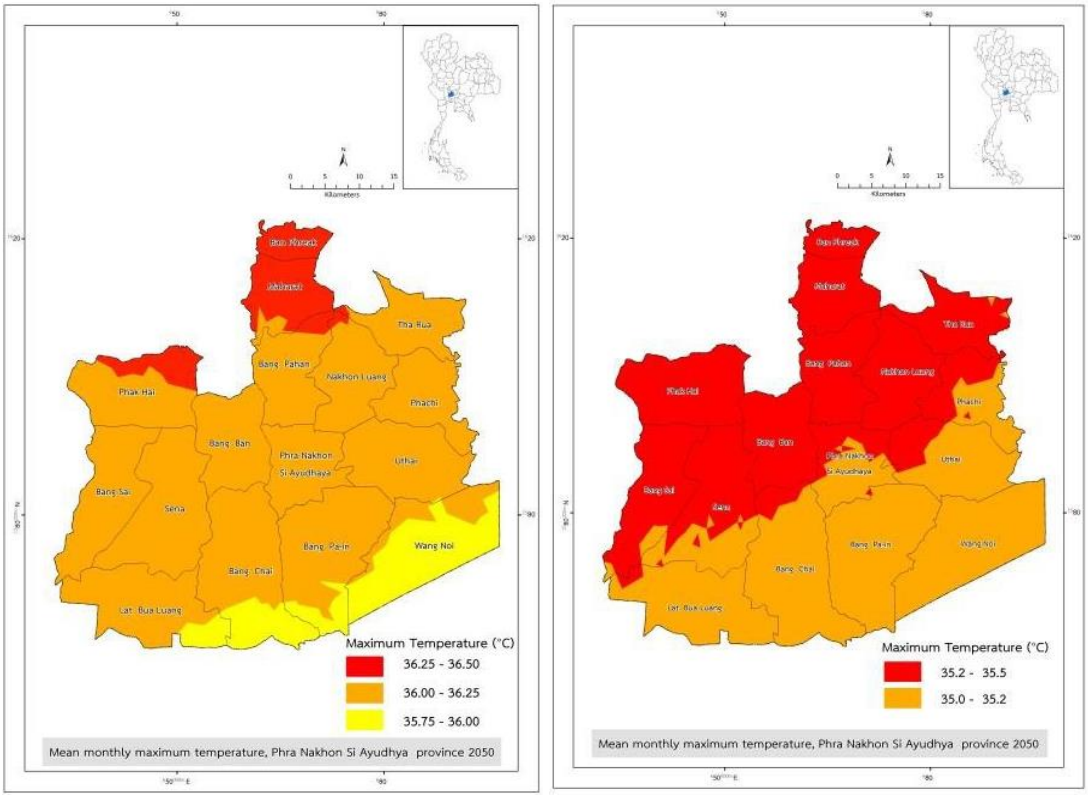


Figure 3 Mean monthly maximum temperature for RCP 4.5 and 8.5 in 2050

Mean monthly minimum temperature

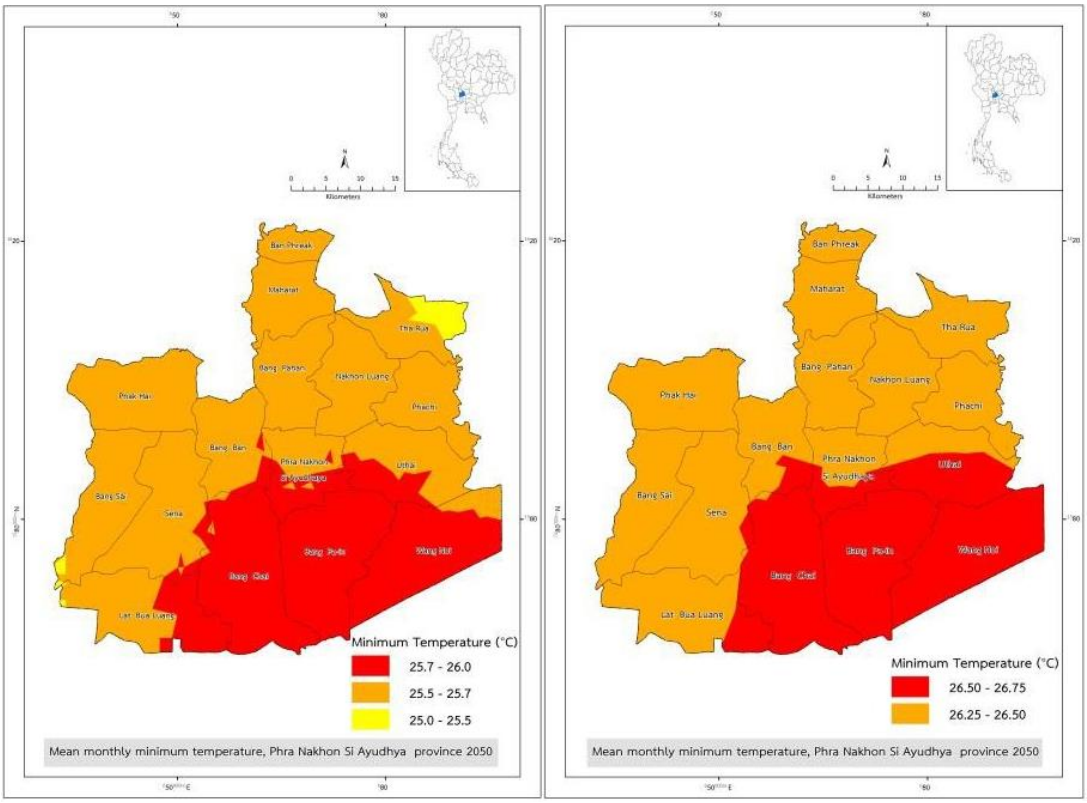


Figure 4 Mean monthly minimum temperature for RCP 4.5 and 8.5 in 2050

Annual precipitation

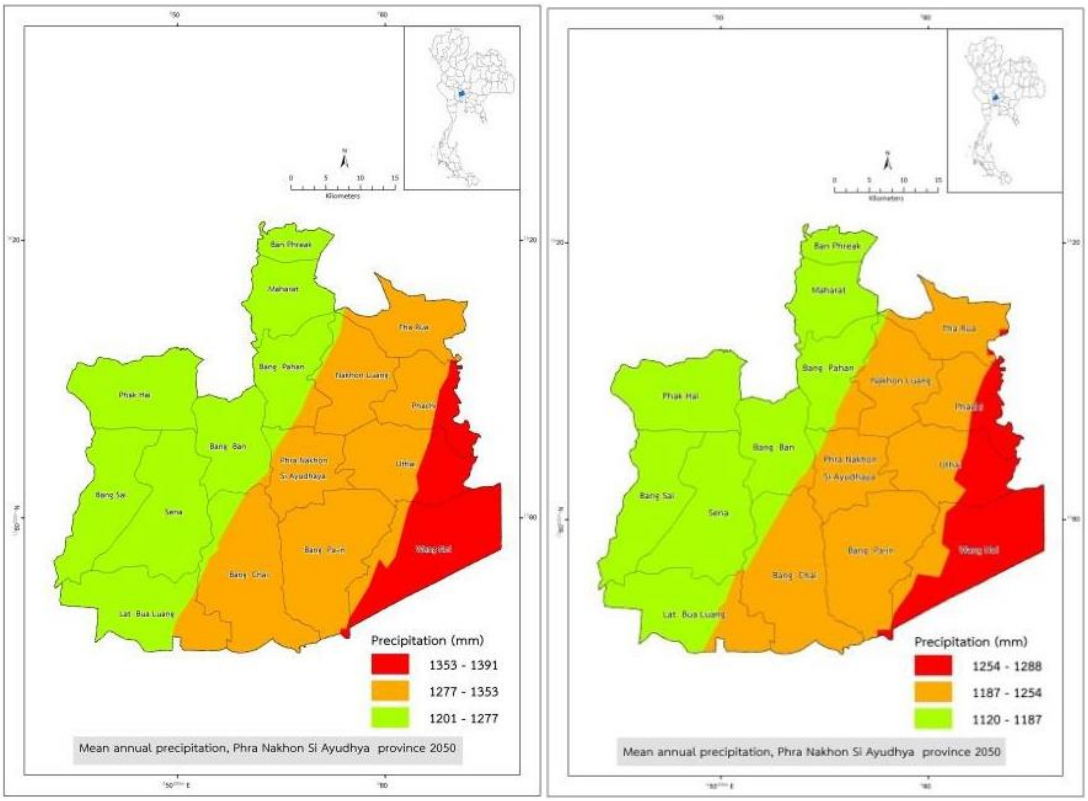


Figure 5 Annual precipitation for RCP 4.5 and 8.5 in 2050

Land suitability for rice

In 27.7 percent of the total land area by 2050 for RCP 4.5 is classified as marginal suitable for rice cultivation, while 71.2 percent and 1.1 percent of total area is classified into very marginal suitable and not suit respectively. In comparison with RCP 8.5 scenario, there is a significant change in suitability level by which 54.1 and 45.9 percent of land area are classified as very marginal suitable and not suitable respectively as shown in Figure 6. It should be noted that land suitability for rice tend to be decreased under highest Greenhous Gas emission (RCP 8.5) than those in stabilizing scenarios (RCP 4.5). Agricultural land is being transformed into residential and industrial use which makes a situation of food production even more difficult to secure food security in 2050.

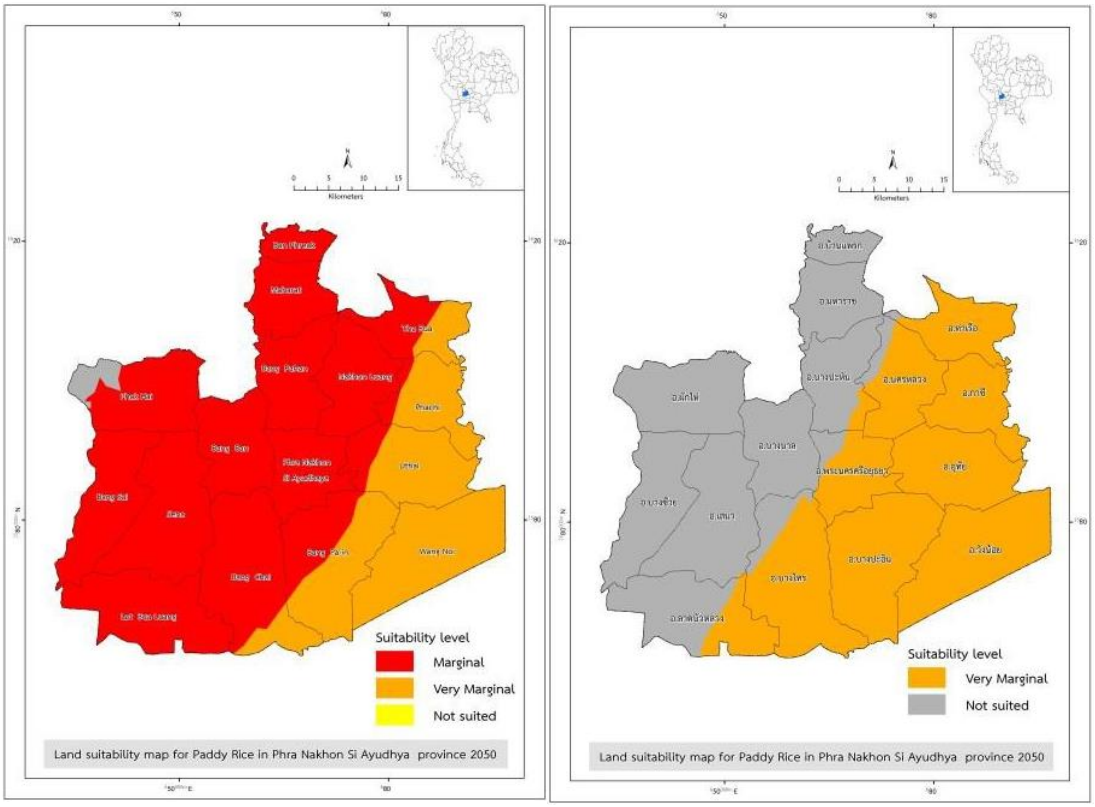


Figure 6. Land suitability for rice by 2050 for RCP 4.5 and 8.5 scenarios

It is very important to consider administrative level's adaptation plan in response to different climate change scenarios e.g. RCP 4.5 and 8.5 due to inherent uncertainty of Greenhouse Gas emission in a future .There are not only climate itself tends to be changing but also includes the frequency of extreme weather events such as flood drought and storm. Implementation of adaptation strategies such as flood retention infrastructure, urban wetland and/or pond and water conservation would be able to secure sufficient water for domestic supply and rice farmland, making it resilient to water related disaster. Other strategies e.g. crop diversification, submergence and drought tolerant rice are should be promoted by government and be implemented by smallholder farm. Land use planning that includes control and optimize land transformation is one of the effective adaptation strategies to slow down urban expansion and impervious surface. To ensure an effective of adaptation practices at farm level, capacity building for smallholder rice farming is necessary to make them understand and improve their farming practices. Knowledge of climate change and effective adaptation strategies, including water management at smallholder level will encourage them understanding climate change process and its impact, including resilient to climate change in order to ensure yields and well-being under uncertainty.

Conclusion

An increasing trend in mean monthly average temperature, maximum temperature and minimum temperature, including the decrease in annual precipitation are expected in Phra Nakhon Si Ayuttaya Province by 2050. The highest annual precipitation occurs in Wang Noi and Uthai districts where agricultural land is a major use of land. Change in mean monthly maximum and minimum temperature for RCP 8.5 is projected to be increased by 0.5-1.0 °C. In consideration of land suitability for rice in 2050 when considering different climate scenarios, there are disappeared of marginal suitable level and significantly increase in very marginal and not suit suitable levels. Shrinking agriculture land will make food security situation worse. Government and all related stakeholders in agricultural sector should take adaptation into their regional and/or provincial plan and policy both short term and long term. Many adaptation strategies such as climate tolerant rice, land use planning and controlling, hard infrastructure construction, and capacity building will play an important role in ensuring rice yields and food security in response to threat from climate change.

Acknowledgement

This work was supported by the Office of the Higher Education Commission, Thailand.

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Installation or Conceptual Art Project with the Ceramics Phenomenon, but How and when?

Em. Prof. Güngör Güner

Abstract

With its formation, going back to thousands of years ago, ceramic is a material fact that the human beings obtain from earth for their emergency needs at first and by time for their different rituals and artistic requirements. Whether it is primitive or developed, ceramic formation requires energy and technology! And once ceramic is obtained, it resists time for thousands of years! Therefore, we have to be very selective when making ceramics! As ceramic artists, we always feel the breath of the tradition of thousands of years on our necks even if we want or not. Contemporary art trends show up one after another and disappear after a while. Meanwhile, *"Is ceramic an art or a craft?"* discussions are brought to agenda. Ceramic artists with a contemporary art education background may tend to keep up with the contemporary art trends because of the pressure caused by these discussions and the dominance of tradition. Among these art movements, Concept Art and Installation under its context still maintain their currency as the most long-lasting one in recent years. Concept is a most important part of the Conceptual Art Project! All materials or finished products that are created or will be created can be an expression tool for the artists. There is no limit here. However, knowing ceramic fact well can provide the ceramic artist with a chance to differentiate. For this reason, I believe that the ceramic artist's concern should be creating ideas that underline being different in the context of ceramic. Using ceramics will be more meaningful if the ceramic object used in the artwork can not be replaced by another object and if the concept changes when the ceramic object is replaced... Ceramic object should challenge as follows: ***"This concept can be expressed only if I am used here!"*** **.....** Forcing ceramic artist to be more creative will prevent the artist from imitation of an ordinary concept art or installation and will add variety to concept art by creating remarkable difference. Surely, this requires a more powerful mind exercise. However, this is the only way ceramic and ceramic artist can accomplish their mission and underline the difference.

Keywords: Installation, Conceptual Art, Project, Ceramics, Phenomenon

Introduction

We, ceramists have countless tools and devices unique of our own those can differ from the other artists. For example; we have our potter's wheel and our wet clay which is born by clay and water meeting that of which every kind of shape can be formed out of it.

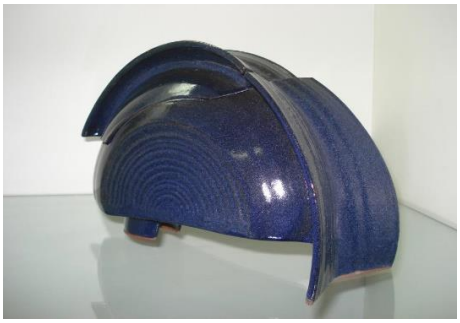
According to definition of German philosopher Martin Heidegger, because of these opportunities, "Ceramist is the person who shapes the space!"

Courses seriously started in Turkey by the end of 50's with State Senior High School of Applied Fine Arts and State Fine Arts Academy. Whereas by the beginning of 80's, as for the education institutions which were taken under the shelter of universities' umbrella and of which their numbers increased, university bachelor and post graduate education and adequacy in art programs and international communication opportunities which can be easily provided when compared to old are concerned, countless researches could have been done; unknown techniques and districts on the subject of ceramics almost left none. This means ceramist's self-expression tools with his work of art became rich.

1. For example, thirty years ago words like Raku, Sagar, Terra-Sigilata, Salt Glossed or Ash Glossed Firing, Paper Ceramics, Ceramics with Silica, Sieve Print, Laser Print, and Photocopy Transfer could be learn theoretical in technology courses but no applications were subject to word! In the parallel of all these stages, development of industry of ceramics and its selling of raw material or auxiliary ready tools and devices to small workshops and artistic studies provide an undeniable contribution.

Some Suggested Working Methods to Trigger to Became Creativity I used to give homework at the freshmen and sophomore classes during my teacher ship process at the Department of Ceramics of Marmara University Fine Arts Faculty in the content of Introduction to Ceramics' Art Education as such: "Do two researches as being upon abstract and concrete with the elements which were turned on the wheel." I want to share with you one, two concepts those I have observed that can trigger palette richness of the ceramist of which has been obtained or proved as a result of this and similar exercise methods, thus our originality.

Picture 1.
A foot sculpture that only a ceramist can realize by using ceramics tools and devices! Here, ceramics concept has not been missed, contrary to that, potter wheel has been used of which jug has been made also with the jug mud, a wonderful work of art which makes feel you that it is challengingly proud with it instead of denying its origin and tradition. The most original and challenging foot sculpture that I have ever seen until today. (artist: Sibel Alparslan my student from Marmara University of Fine Arts Faculty)

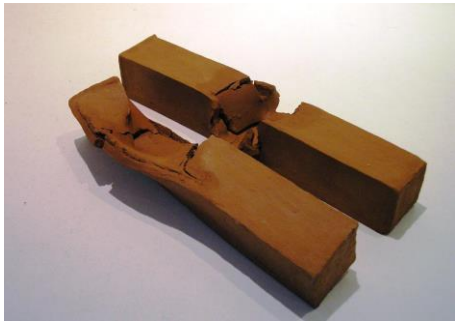


Picture 2.

A container sculpture realized by elements turned on potter's wheel In the context of homework above. (artist**: Sule Dönmez,** a student of mine from Marmara University Fine Arts Faculty)

Another homework that I have given to students in the context of Introduction to Ceramics Art Education was: "Realize a form preferably as it is going to be space internally upon and later deform it; but in the process of this deforming, main form and your method of deforming must be readable.

Picture 3.
Cylinders which have been turned on the potter's wheel, a shape change has been provided by mounting over the figure on them while they were wet. By which another material can such a fresh and organic deformation be provided?
(artist: **Uğur Örsöz,** a student of mine from Marmara University Fine Arts Faculty)



Picture 4.

A breach event realized by utilizing of the fragility of the clay after it is dried or fired as it is shaped. This is a very extremely unique privilege that can only be on ceramist' palette.
(artist**: Duygu…** a student of mine from Marmara University of Fine Arts Faculty

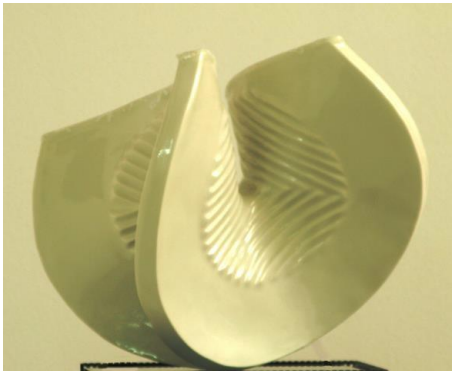
Picture 5.

One of the biggest privileges of the ceramics is its taking its last form by being fired at 900– 1400 ˚C.
The seen form deformation event can only be thought by a ceramist; as the kiln is an important element of ceramic language.
Before entering into the oven, this work of art was an object in its square with every of its way!
(artist: **Zeynep Mandıra,** a student of mine from Marmara University Fine Arts Faculty)

Picture 6.

Here the plate form, with ceramic casting mud, into casting mold of gypsum is poured several times. The castings were made with specially as faulty and different colored mud. Then, the faulty and unfinished plate forms were too added on top of the other.
It is only a very unique fact that only the ceramic artists can think and practice it.
(artist: **Aynur Karakaş)**

Picture 7.
Realized in the direction of the above suggestions; the name of this settlement is: **"The alcohol does not stand as it stand in the bottle"**The bottles which are being deformed gradually and at last which sees the basement! This is a work of art that only a ceramist can think and realize. It seems that all of the elements like the potter's wheel, the wet of the clay and as a consequence its form's deformation gathered together in order to form the concept which is subject to word. Is it possible here to place another thing instead of ceramics? (artist: **Hayali Dimiler,** a student of mine from Marmara University Fine Arts Faculty)




Picture 8-9

Above is the sculpture of which its casting has been made with the classic porcelain clay at right locked in a close embrace appearance of the sculpture after firing that of which is two of its casting in number have been made into the same pattern with paper porcelain clay and those of which firing have been made as it is positioned side by side in the oven...A gift of a different body and oven, to us; to ceramists, as an unforeseen gift, beforehand. But a very valuable element that can only be at the ceramists' palette after it is experienced once. (Its artist: Güngör Güner)


Picture:10-11

The same form as nr.8-9, Ø:45; h:28cm **The glass sculpture** you see on the right was made with the method of **Páte de Verre.**

The first construction of the statue was unsuccessful. I broke it and grinded it in a water ball-mill. So the glass pebbles you saw inside the stand were formed. By the way the glass fragments were rid of the waste and I have got the exclusively stones that only a ceramicist could make it.

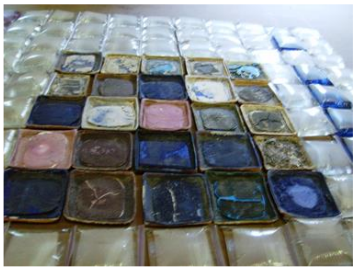
Picture12-13.
Mule beads made by sole silica body in Iran's City of GUM (sand); they are fired by being lined into a special mixture of ash and the products can be extracted from inside of mixture of ash as their every side are glossed and they are not sticking to any place after the firing. I first had the information about this technique in 1980 by the help of the article that Barbara Kleinman has published in the Keramik Magazine. Later on, I made several researches about different ashes and pigments which give color and published these researches. (Look at: 1992 The Book of Notifications of Turkish Ceramics Association: "Story of a Nile Blue", page: 619 – 621, publishing Number: 5)

Picture 14. After firing and cleaning from ash mixture of the Mule Bead

The story of my own installation.

It wasn't directly my aim to make mule-beads if I made some research about the silica ceramics fired as embedded in an ash mixture. My main goal was: How can I make an art work out of, with this magic, traditional mule-beads technique of İran.

So, I will present the story of the concept blow. Which takes place in the content of a serial workout that has been going on since 1993 with the subject of **"I am Displaying The Water"** On line with the suggestion above. Besides which factor came together and what kind of event triggered this art work.



Picture 15-16. Güngör Güner,2007 on the wall.Paper-Clay mirrors with silica-slips and the water ınstallatıon on the bottom

I AM DISPLAYING THE WATER

Yes, since 1993 I am exhibiting water (H2O), without which life is impossible and of which the abundance can be as destructive as its shortage What is interesting is this **miracle** called **water** that is colorless, odorless, transparent liquid and can take the form of its container. It consists of two chemical elements, of which one helps burning and the other is flammable!

Picture 17.

Güngör Güner
From the series of " **I am displaying the water " 2004**
(80x80x05 cm).3+(80x10x05cm) Ash glaze on red clay, 1150° C

Hydrogen

Two units of tasteless and odorless hydrogen, of which the chemical symbol is **"H"**, which is in gas form and has the smallest atomic weight (*1 gr*) in the periodical table and has the least bonds (*1 piece*) and is used to obtain steel-welding requiring high heat when burned, go into reaction with one unit of oxygen and become water (H20). Being converted into water when reacting with oxygen, this innocent element **"H"** can be used to obtain **H** bomb, which has a very strong destructive effect, when its atomic nucleus is composed instead of decomposed. Moreover, hydrogen has another extraordinary feature as its melting point is-259.8 °C and boiling point is -258.8 °C.

Oxygen

Oxygen of which the chemical symbol is **"O"**, atomic weight is 16 gr, which has 2 bonds and is normally in gas form; forms 50% of the earth, 23% of the air we breathe and 27% of the water and finally the second element of water that enables us to breathe… Its melting point is -218.7 °C and boiling point is -182.97 °C.

Combustion cannot take place without oxygen! Therefore, each oxidation is actually a combustion process. It takes place very slowly at normal heat. For example: Corrosion of iron, wearing of wood, even activities in our body caused by breathing and countless combustion events, of which the flames can be observed, at high levels of heat.

As a result of slow combustion (oxidation), metal oxides are generated and known ceramic products are produced as a result of different combination and processes of heat resistant metal oxides.

Belief and Water: When we examine the perspective in mythology and divine religions related to water; we see that they all agree with the same view: **"WATER IS GOD".** When it rains, they say **"It's raining grace"** in Anatolia… The lexical meaning of **grace** is **God!** The drive in all kinds of existence in mythology or divine religions is a divine energy!

Picture 18

Detailed from picture 17

Picture 19.

Güngör Güner, **Relationship Between Earth -Water and Transparency 1993,** 330x290 cm, Embedded quartz ceramics in ash glaze represent the formation of earth; colored and colorless water in plastic bags express that sometimes earth can pollute water and sometimes water can pollute earth!"

Why am I Displaying the Water?

I was born in Omerli village in Beykoz-Istanbul but I spent my childhood in an old wooden house with a garden in Usküdar when the population of Istanbul was nearly one million. Water cut we used to experience every once in a while was a natural part of our lives. What a grief it was… Hamidiye Fountain was close to our house… Fifth floor of an apartment building, where I was going to live for twenty five years, in Maçka when Istanbul became a desert of apartment buildings with a population of twenty million. The only time we could have water there was midnight.

And the year 1993 was the driest year I had ever seen. It rained neither in summer nor in winter. The trees were bone-dry although it was spring. Then the rain came but it

didn't fall on ground! The trees caught all the rain and burst into bud and bloomed the other day. Then it rained again and all rain was captured by the trees without letting it fall on the ground. Next day all of them came into leafs. Meanwhile, it became impossible to have water on the fifth floor and I started to carry buckets of water to the fifth floor only when the doorman a favor to fill my buckets… One day an American friend of mine forgot 1-2 pieces of quadrangular plastic bags that can automatically be closed in my house. As I was used to do so, I immediately filled the bags with water. Water bags lined up in the bathroom were looking really nice… During those days, I was preparing to open a ceramic exhibition in an art gallery that was converted from an old tradition Turkish Bath.

Suddenly I realized that somehow I could exhibit these bags as well.

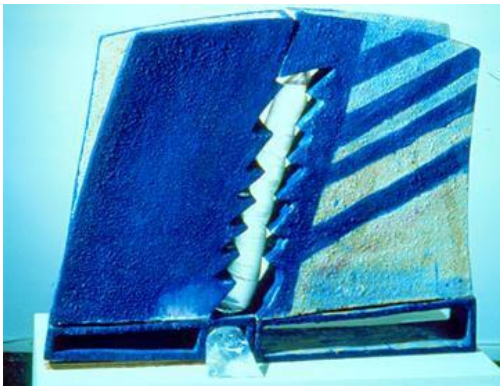
I intended to give the viewers that message**: "**Water is now so rare that it can be exhibited in an art gallery**"** This was the first installation I made and it was totally a result of conditions, not an imitation !

The manifest of the installation was carrying on**: "**The need and invention of the Mankind to make pots from clay go back to the end of the Neolithic Age, which is 7000 years ago. Therefore, the relationship between ceramic and water goes back to those ages. However with this artwork, I wanted to achieve a new, free and individual aspect as regards this ceramic- water relationship and giving them a new dimension. Moreover, I wanted that the people may kindly take note some messages as well as I aimed to give them.

For example: I tried to draw attention to the fact that water has become so rare and valuable that it may be shown at least in the exhibition halls in these days. In spite of the unavoidable usage with simultaneous damnation of the unloved plastic bags, these latter nevertheless justify in the newest material "plastic" and the oldest material "ceramic" how they unite and marry for an art work and surprise us their joint….

Picture Picture 20
Güngör Güner, ***I am Displaying the Water,1999*** *h:225 cm, w:60cm, d:25 cm Ash glaze on fireclay,1150 °C*

Thus, I have been exhibiting water since 1993 I continue to work on the **"I am Displaying the Water "**concept. I keep on making objects to be filled water and realize my two or three-dimensional art works to exhibit water in a visible and touchable way when my muses visit me….



Picture 21. Güngör Güner, ***I am displaying the Water, 1999*** *h.70 cm, w:120 cm d:12 cm.ash glaze 1150 ˚C*

Picture 22.
Güngör Güner, ***I am displaying the water 1993*** h.80 cm,w:70 cm,d:12cm
Ash glaze on fireclay 1150 °C

Picture 23.
Güngör Güner ***Kaskad, 2000*** *h.160 cm ,w:35 cm, Ø:12, Ulaksit glaze on Fire Clay 1150 °C*

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Computer Simulations of Ethics: The Applicability of Agent-Based Modeling for Ethical Theories

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Abstract

I consider the applicability of Agent-Based Modeling (ABM) and computer simulations for ethical theories. Though agent-based modeling is already well established in the social sciences, it has not yet found acceptance in the field of philosophical ethics. Currently, there are only a few works explicitly connecting ethics with agent-based modeling. In this paper, I show that it is possible to build computer simulations of ethical theories and that there are also potential benefits in doing so: (1) the opportunity for virtual ethical experiments that are impossible to do in real life, and (2) an increased understanding and appreciation of an ethical theory either through the programming implementation or through the visual simulation. In the first part of the paper, I mention some social science simulations with ethical import that could encourage ethicists to work with ABM. Second, I list the few pioneering works that attempt to combine computer simulation with philosophical ethics, the most prominent being *Evolving Ethics: The New Science of Good and Evil* (2010) by Mascaro et al. Third, I give pointers for the computer simulation of the most prominent ethical theories: deontological ethics, utilitarianism, feminist care ethics, and virtue ethics. In the final part, I consider the potential of using an existing reference model for the simulation of human behavior, the PECS model, as the foundation for a computer simulation of virtue ethics.

Keywords: Ethics, Computer Simulation, Agent-Based Modeling, Virtue Ethics

Introduction

Agent-Based Modeling (ABM) is an established approach in the computational social sciences. It uses computers to simulate the behavior of "agents." Agents may be molecules, organisms, or other entities, but in the context of computational social science, they normally represent human beings with certain behaviors. The interactions of agents with other agents, or agents with their environment, can lead to different results depending on the assignment of specific conditions and values. They can also lead to unforeseen or surprising results called *emergent* behavior, where a complex property at the macro system level is produced that is not encoded at the individual agent level

(Axelrod, 1997, p. 4; Wilensky & Rand, 2015, p. 29). The possibility of running such computer simulations over and over with different variables make them function like digital laboratories where one can perform experiments and test hypotheses (Epstein & Axtell, 1996, p. 4; Gilbert & Troitzsch, 2005, p. 14). They are particularly attractive for social scientists because many social experiments cannot be practically (or ethically) carried out in the real world.

Though many social scientists have embraced ABM as a promising approach to conducting social science research, the same cannot yet be said for ethical and moral philosophers. Many philosophers discuss the ethics of computers and technology, but there are only a few who *use* computers—and in particular, computer simulation—to conduct their research on ethics. Given this situation, this paper explores the potential of computer simulation to be used for the benefit of philosophical ethics.

Social Science Simulations and Ethical Implications

Many of the phenomena that computational social scientists study have ethical implications. For example, the first attempt to apply agent-based modeling to social science was by Thomas Schelling. In his book *Micromotives and Macrobehavior* (1978), he presented a model that showed how housing segregation between races could occur even if no individual wanted it specifically, so long as these individuals had a preference not to be an extreme minority in their neighborhood. In other words, individual preferences and actions resulted in large-scale consequences that none of the individual agents actually intended. This phenomenon could be witnessed in the simulation where two populations of different colors would begin mixed together, but slowly start to form their own homogenous neighborhoods. One could also adjust parameters such as the percentage of tolerance of agents to having different colored neighbors. This results in different kinds of segregation. Though the dynamics explored in the simulation were not of a directly ethical nature (the individual preferences and the resulting segregation were not themselves judged as being right or wrong), it obviously touches on many sensitive ethical issues in the real world such as racial discrimination, unequal opportunities and development in cities, etc.

A more recent trend in social science simulation is the investigation of trust. Doloswala investigates the behavior of peer groups when confronted with the discovery of a liar in their group (Doloswala, 2014). Using proximal space to represent the idea of "shared cognitive space," they simulate how a discovered liar would be ostracized from the group depending on different parameters such as the probability of being discovered, the penalty for lying, and the forgetfulness of agents. According to their simulations, the forgetfulness of agents plays a greater role in shaping groups than the penalty for lying. Meanwhile, Lim et al. investigate the interplay between trust at the level of individuals and the development of collective social moral norms (Lim, Stocker, & Larkin, 2008). They call their resulting model a Computational Model of Ethical Trust (CMET), a two-tier architecture that utilizes both agent-based modeling and artificial neural networks.

Kim (2009) and Tykhonov et al. (2008) investigate trust in the context of supply chains and networks. Kim finds that as a trust relationship between trading partners is prolonged and uncertainties about the trustworthiness of trading partners are diminished, one sees a greater stability in their inventory levels over time. This occurs even without any explicit information sharing among trading partners regarding the status of their own inventories. Meanwhile, Tykhonov et al. employ a human "trust and tracing game" with real-life participants to collect data for trust, deceit, and negotiation behavior, and then use that data to inform a computer agent-based model. They hope that this combined research method will produce a model that is more applicable to real-world trade processes.

In these computer simulations, the researchers touch on many ethical issues. For example, they discuss the importance of being recognized as "trustworthy" by others, the damage and disruption caused by lying and deceit, the benefits of a strong trust relationship, etc. Though none of them refer to any ethical theory, there is no obvious reason why an ethical theory cannot be employed to interpret and engage with their data and results. It is clear that social scientists are able to use computer simulations for studies with ethical import. Can philosophers use computer simulation for ethics itself?

Computer Simulations and Ethical Theories

Robert Axelrod is famous for the computer tournament he organized for the iterated Prisoner's Dilemma[1] where many different strategies were submitted from all over the world and matched with each other in round-robin (Axelrod, 1984). The strategy TIT FOR TAT—which first cooperates then subsequently replicates the other player's previous action—emerged as the winner of the entire two-tier tournament. The tournament was not itself an agent-based model, but similar to one in that "agents" (with respective strategies) interacted with all the other agents in the virtual arena. The project also did not espouse any particular ethical theory, though it did explore real-life examples of the TIT FOR TAT strategy. Eventually, Axelrod attempted to move beyond the two-person format of the Prisoner's Dilemma and explore how cooperation could emerge between many individuals simultaneously. In order to do this, he consciously resorted to agent-based modeling (Axelrod, 1997). With the use of ABM, he was able to explore social phenomena such as the promotion of norms, choosing sides, and the formation of new political groups. He was also able to introduce the evolution of

[1] The Prisoner's Dilemma is an imaginary situation employed in game theory. Two prisoners are accused of a crime and placed in separate cells. If one of them confesses and the other does not, the one who confesses receives only 1 year in prison, while the other who does not confess receives 4 years. If both of them do not confess, they each receive only 2 years. If they both confess, they each receive 3 years. While deciding on what to do, they are unable to communicate with each other. Clearly, the greatest payout is if one confesses while the other does not, and we might expect a prisoner to pursue this action out of self-interest. However, the other prisoner might also have the same mindset, and if they both pursue their self-interest, they would be in a worse situation (3 yrs. each) than if they both keep silent (2 yrs. each). What is the best thing for a prisoner to do? Confess (sometimes called "defect") or not confess ("cooperate")? The Prisoner's Dilemma is a one-shot game where both players make their moves simultaneously. In comparison, the iterated Prisoner's Dilemma allows for many moves and a memory of what transpired in the previous moves.

strategies through genetic algorithms. Though containing much ethical import, these simulations did not refer to any particular ethical theory.

Building on Axelrod's work, Peter Danielson was perhaps the first person to explicitly address a philosophical ethical theory with the use of a computer simulation. He coined the term "artificial morality" for a combination of game theory and artificial intelligence used to develop an ethical theory called *instrumental contractarianism*, which is partially based on the work of David Gauthier (Danielson, 1992, p. 17). He used an Extended Prisoner's Dilemma which involves two sequential moves instead of the two simultaneous ones in the traditional Prisoner's Dilemma. He also eschewed the iteration found in Axelrod. The tournament tested whether the "constrained maximizer" of Gauthier, which cooperates with those who cooperate and defects with the rest, really fares better in every case over "straightforward maximizers" (which includes TIT FOR TAT). His simulations answered in the positive. However, according to him, there is apparently another agent, a so-called "reciprocal co-operator" (which cooperates only when cooperation is necessary and sufficient for the other's cooperation), that fares better than Gauthier's constrained maximizer in a varied population environment.

An unexpected conclusion from Danielson is that his "artificial morality" applies more to formal organizations, firms and machines than to actual people (Danielson, 1992, p. 198). According to him, this is because of the lack of cognitive transparency on the part of human beings as well as the unpredictable and lasting influence of emotions. As he says, "it should not be surprising if traditional human morality fares poorly in terms of rational performance... Artificial Morality may lead us to discover techniques of communication and commitment that are morally effective but unavailable to unaided human beings" (Danielson, 1992, p. 201). Regardless of the controversial conclusion, Danielson's work is noteworthy for being the first to combine a philosophical ethical theory with a computer simulation, though his simulation was a tournament in the style of Axelrod and not an ABM.

Alicia Ruvinsky has called for "the integration of computer simulation and ethics theory... an agent-based simulation mechanism that takes a computational perspective to ethics theory" (Ruvinsky, 2008, p. 76). She uses the term "computational ethics" for this project but this can be confusing since people also use the same term to refer to ethics for AI (i.e. machine ethics) or ethics for computer programmers, so I do not follow her in calling the combination of computer simulation and ethics "computational ethics." Her short article does not give any implementation but only some rough suggestions. According to her interpretation, "an ethic is a moral framework characterized by rights, liberties, and duties, which are parameters in an ethic model" (Ruvinsky, 2008, p. 77). She then claims that ethical theories such as deontological ethics and divine command ethics can be quantified using these parameters. Once such ethical theories are quantified, one can simulate artificial societies where agents can adopt different ethical theories and interact with each other.

These simulations are useful in considering emergent effects of distinct moral perspectives within a society. For example, what kind of social ethic would emerge in a simulation of the Prisoner's Dilemma in which half of the population adopts a Kantian ethic model while the other half adopts a rational agent model? (Ruvinsky, 2008, p. 79).

Though she refers to the Prisoner's Dilemma, it seems like the simulation she envisions is an ABM with an interacting population and not a tournament in the style of Axelrod and Danielson. How one quantifies ethical theories using the parameters "rights, liberties, and duties" is not shown in any detail. I doubt that one can quantify ethical theories such as care ethics and virtue ethics based on these parameters alone. Nevertheless, Ruvinsky is noteworthy for being one of the few voices encouraging the computer simulation of ethical theories through agent-based modeling.

The first ever computer simulation of an ethical theory using ABM was done by Mascaro et al., as presented in their book, *Evolving Ethics: A New Science of Good and Evil* (Mascaro, Korb, Nicholson, & Woodberry, 2010). Their simulations were programmed in NetLogo, currently the most popular and accessible ABM software package. They first developed an evolving world where agents could move, eat, reproduce, and also pass on certain traits and behaviors to the next generation. Next, they used act utilitarianism to address the ethical status of controversial acts such as suicide, rape, and abortion in this evolving world. They chose act utilitarianism as the normative ethical theory because they think it is right and also because, according to them, it is "the only ethical system which *allows* us to measure the outcomes of computer simulations and judge them as better or worse" (Mascaro et al., 2010, p. 5). In other words, it is the only ethical theory that can be usefully quantified for computer simulations. All the other ethical theories, such as deontological ethics, virtue ethics, and even rule-utilitarianism "depend upon the exact semantics of the deontic principles or the virtues, respectively, and incorporating semantic understanding into artificial life simulation in any kind of sophisticated way requires a prior solution to the problem of natural language understanding" (Mascaro et al., 2010, p. 32). I strongly disagree with this point, and I hope to show in the next section that this is not the case. It may be that act utilitarianism is more *straightforward* to simulate than other ethical theories because what is minimally required is a quantification of the utility from every act, a single numerical variable. But other ethical theories can also be quantified without recourse to natural language understanding.

Mascaro et al. remind us that according to utilitarianism, what is good is what maximizes "the sum of expected utilities *across a population*" (Mascaro et al., 2010, p. 29). Though acknowledging that in real life, "what utilities themselves are is not exactly clear" (p. 27), they simplify things in their simulation by connecting utility to the variable, "health," which accounts for both physical and psychological health. An act that is committed is good if it produces greater utility (health) for the whole population than if the act was not committed. Fortunately, with computer simulations, this can easily be done and measured. A batch of simulations (perhaps with varying environmental conditions) can be run with act X turned on, then an equal number of simulations could be run with act

X turned off. The utility scores between the simulations can then be compared. In the case of Mascaro et al.'s work, simulations were run where suicide, rape, and abortion were present, and also where they were absent. These simulations spanned several generations of agents or thousands of digital years. Their findings reveal that suicide and abortion can in some extreme cases be ethical, namely when there is a scarce supply of food such as during a drought, while rape is always unethical because of the unavoidable health costs for the victim, both physical and psychological.

One could question aspects of their implementation. First of all, the values for negative and positive utilities must be determined by the programmer. "Those utilities are fixed, being selected to reflect the real world to some approximation" (Mascaro et al., 2010, p. 89). So for example, in the rape simulation, when a victim is raped, the victim derives a large negative utility of -70 health units (additionally, if there is offspring produced, the victim will have to invest anywhere from -590 to -110 health units as parental investment) and the rapist derives a small positive utility of 5 health units. If the rape is prevented according to a "rape prevention probability" variable (either 0.9, 0.75, or 0.5 depending on the experiment), then the targeted victim experiences a smaller negative utility of -10 health units while the rapist suffers a large negative health effect of -60 health units and negative utility of -15 health units, representing the rapist being punished (Mascaro et al., 2010, p. 186). Why a negative utility of -70 and not -100 or -150 for being a rape victim? Is it also reasonable to keep the negative utility constant in every case or is it better to introduce some fluctuations? Mascaro et al. acknowledge that in principle the value need not be fixed and can perhaps evolve over time (Mascaro et al., 2010, p. 96). However, this issue of setting appropriate values for utility presents a challenge for anyone who wants to simulate utilitarianism.

Second, whether it is "utility" (e.g. psychological trauma) or a more neutral "health effect" (e.g. giving birth) that is being referred to, they both involve "health units" and contribute to a single numerical variable called "health." This can be confusing because it is not clear whether utility is essentially different from health or the same as health. It seems that utility and health are distinct from the point of view of the simulator but not from the point of view of the virtual agent, who experiences both simply as health.

Despite these implementation problems, the greater value of the work of Mascaro et al. is its pioneering endeavor to simulate a specific ethical theory with ABM. Given the exploration of acts of suicide, rape, and abortion in multiple worlds and over many thousands of virtual years, it is obvious that one can do ethical experiments in computer simulations that one cannot do in real life. In fact, they call their project a "new science" and an "experimental ethics" that introduces a new methodology to the study of ethics. To the objection that their simulations might be too simple or naive, their answer is likewise simple: "go forth and simulate better!" (Mascaro et al., 2010, p. 236). Indeed, the controversial aspects of their work should be a spur to others to see how computer simulations of ethics could be better undertaken.

Prominent Ethical Theories

In a brief Internet article, Mike Loukides of O'Reilly Media speculates about "an AI that can compute ethics" and considers how the three major ethical theories of deontological ethics, utilitarianism, and virtue ethics might be considered "optimization problems" for a machine to solve (Loukides, 2017). He himself is skeptical about such a prospect but recognizes that these ethical theories indeed have features that are, in theory, computable. "It isn't surprising that computational ethics looks like an optimization problem. Whether you're human or an AI, ethics is about finding the good, deciding the best way to live your life" (Loukides, 2017).

I now turn to prominent ethical theories, namely deontological ethics, utilitarianism, feminist care ethics, and virtue ethics, and consider how they can also be simulated on the computer with ABM. I only provide pointers and suggestions for their simulation, not any technical implementation. But I hope that these will be enough to show that their simulations can be done.

Deontological Ethics

Kant's categorical imperative is as follows: "Act only in accordance with that maxim through which you can at the same time will that it become a universal law" (Kant, 2002, p. 37). As Christine Korsgaard explains,

[Kant] suggests that the way to test whether you can will your maxim as a universal law is by performing a kind of thought experiment, namely, asking whether you could will your maxim to be a law of nature in a world of which you yourself were going to be a part... Kant's test may be regarded as a formalization of the familiar moral challenge: "What if everybody did that?" In order to answer this question, you are to imagine a world where everybody does indeed do that. (Kant, 2012, pp. xx-xxi)

Any maxim that passes this test counts as a duty, and a duty ought to be followed no matter what. It should not be influenced by any external factors, emotions, or unforeseen consequences.

Implementing this ethical theory in a computer simulation is challenging. One could at first suggest that it is easy to apply deontological ethics to the world already provided by Mascaro et al. To see whether suicide is a duty, simply have all the agents commit suicide in one simulation and observe what happens. But even in this trivial example, this would be a deontological ethics on the part of the experimenter who is not *part* of the virtual world itself. A unique aspect of deontological ethics is that it is an ethical theory that the *agent* doing the act needs to know and implement. The theory cannot be applied from *outside* as might be the case with utilitarianism or virtue ethics. In these other ethical theories, a person may act ethically (by maximizing net utilities or by performing virtuous acts) without consciously subscribing to utilitarianism or virtue ethics. In contrast, one cannot act ethically according to the categorical imperative without knowing it. It needs to be conscious and deliberate. This is also apparent in the

third formulation of the categorical imperative called the "formula of autonomy," which considers the will of the agent as the source or giver of universal law, i.e. the universal law cannot come from outside the agent (Kant, 2002, p. xviii).

Given this special condition, we need to add a more complex "cognitive architecture" to properly render deontological ethics. There are many cognitive architectures that have been developed for agents, one of the most well-known being the BDI (Belief, Desire, Intention) architecture (Rao & Georgeff, 1995).[2] However, without going into the details of any specific cognitive architecture, I suggest that the way to simulate deontological ethics is through a "simulation within a simulation." An agent must have the capacity to simulate another simulation in its head (a second-order simulation). Assuming that the agent subscribes to the categorical imperative, then before it performs a certain act (perhaps given to it as an option by the programmer or randomly generated), it must be able to imagine (simulate) a world where all other agents in its present world did the same act (for the sake of the example, let us assume that the agent is a powerful rational agent who knows everything about its present world).[3] This second-order simulation will be evaluated as either good or bad based on some standard. If it is good, then the agent will identify the said act as a *duty* and perform it.[4] If it is bad, then the act will not be performed.

How will the agent decide if the imagined world is good or bad? Should it be *better* in some way than the present world for it to be regarded as good? If so, in what way? If one considers the benefit to all the agents in the world then it would be similar to utilitarianism. My tentative answer is that the second-order simulation should be *sustainable* and *balanced*. Kant speaks of a universal maxim as a "universal law of nature," and nature usually tends to a kind of sustainable equilibrium. The imagined world should be *sustainable* in that the second-order simulation could continue for *n*-number of generations without any kind of catastrophe. A universal maxim of abortion obviously cannot be sustained because there would be no more agents by the next generation. On the other hand, a universal maxim of reciprocal helping could be sustained for an indefinite number of generations. How far ahead into the future the agent can look will depend on the programmer. Second, the imagined world should be *balanced.* This is more variable and could mean any number of things depending on what can be found in the first-order simulation. If agents possess wealth in the simulation, then *balanced* might equate to every agent having at least 1% of the total wealth in the world, with no single agent having more than 10%. A world where three agents ended up with 90% of all the wealth in the world would then count as *imbalanced*, something the rational agent would never consent to. Therefore, a universal maxim that leads to

[2] For a survey of cognitive architectures for agents, see Balke and Gilbert (2014).

[3] Because the second-order simulation depends on the state of the present virtual world (first-order simulation), this also gives some variability in what will count as a duty. What counts as a duty at one point could change over time as the conditions of the present virtual world change.

[4] There is also the complicating factor of how *often* the act should be performed as a duty. Every tick of the simulation? Once every cycle? For the sake of simplicity, we will ignore this issue here.

this kind of imaginary world would not count as a duty and will not be performed by the agent.

These suggestions can be refined further but I hope they show that there is a way of simulating deontological ethics which stays true to its special condition. It requires a "simulation within a simulation" or second-order simulation conducted by the deontological agent. Complex as it may sound, this arrangement is possible with current computing power and programming resources. It would be computationally taxing if we require that second-order simulations need to be conducted by agents for every single act. More efficiently, agents could just remember what they have identified as duties and reserve the second-order simulations for brand new acts. It could also cause significant slowness if we have many deontological agents doing second-order simulations at the same time. But if well executed, we could have a simulation with agents only doing acts that, according to their own reason, should be universal laws.

Utilitarianism

In their book, Mascaro et al. mention an interesting method for act utilitarianism:

Calculating the cumulative utilitarian effects of a specific act, e.g. a specific suicide, is straightforward enough. At the point in our simulation where the suicide occurs, we can fork the simulation, with one process containing the suicide and the other excluding it, and then compare the consequences. (Mascaro et al., 2010, p. 179)

They do not adopt this method because they claim they are more concerned with *kinds* of acts rather than individual acts, and also that this method would be impractical. However, this forking method is more faithful to act utilitarianism than the method that they adopt and should be developed by anyone wishing to construct a better simulation of act utilitarianism. The kind of act utilitarianism that Mascaro et al. have, which turns a particular action on or off for different simulations and then compares the results, is in fact not very far from rule utilitarianism. Rule utilitarianism in its simplest form states that an action is right if it follows a rule that leads to the greatest good. However, issues such as what it means for a specific action to *follow* a rule, what counts as a rule, and whether exceptions to the rule are permissible (especially those that maximize utility), have led to different versions of rule utilitarianism (Lyons, 1965). Without discounting the complexities and nuances involved, let us here consider a simplistic version of "strong rule utilitarianism" which holds that if a rule contributes to the greater good, it is always right to follow that rule and always wrong to break it.

Mascaro et al.'s simulations seem to already contain everything needed to explore this kind of strong rule utilitarianism. The effect of the rules, "one should not commit suicide," "one should not commit rape," and "one should not commit abortion" can already be observed in their simulations, namely, in simulations where those actions are turned off versus those simulations where they are turned on. However, the method of assessment for rule utilitarianism will be different from theirs since, as I understand it, rules are

more temporally independent than actions. Instead of looking at the net utility of a total population at a given time period (such as in a time of drought), one should look at the net utility of the total population over the *complete timeline*, i.e. the whole time span of the simulation. If the supertemporal, intergenerational net utility in the simulation where suicide is turned off is greater than the supertemporal, intergenerational net utility in the simulation where it is turned on, then the rule "one should not commit suicide" contributes to the greater good and the act of committing suicide is unethical in all cases, even in times of drought.

I will not dwell on this point because this strong rule utilitarianism is only a simplistic version and there are better and more nuanced versions of rule utilitarianism that cannot be discussed here. However, as mentioned in the previous section, I think where Mascaro et al.'s work can be improved is in the designation and assignment of utility. This will apply whether we use act utilitarianism or rule utilitarianism. Though they connect utility in their simulation with health, they recognize that there are many other sources of utility. For example, in the case of rape, the negative utilities are not only on account of the direct psychological and physical harm but also involve long-term trauma, negative utilities to the relatives and friends of the victim, etc. (Mascaro et al., 2010, p. 185). A more complex virtual world where long-term memory and emotions are included, as well as human social relationships, would allow for a better simulation of utilitarianism. In the last section, we discuss the PECS reference model as something that could work well with virtue ethics, but it could have benefits for utilitarianism as well.

Feminist Care Ethics

As a response to the two rational and *masculine* ethical theories mentioned above, Nel Noddings introduces a care ethics that she says is more *feminine* in its approach, an ethic that "has a proper regard for human affections, weaknesses, and anxieties" (Noddings, 2013, p. 25). According to her,

Caring involves stepping out of one's own personal frame of reference into the other's. When we care, we consider the other's point of view, his objective needs, and what he expects of us... Our reasons for acting, then, have to do both with the other's wants and desires and with the objective elements of his problematic situation. (Noddings, 2013, p. 24)

The concrete relationship between the "one-caring" and the "cared-for" is considered basic. In the caring relationship, the "one-caring" has an affection and regard for the "cared-for" that is not bound or dictated by rules. At the same time, the "cared-for" usually has an awareness of this affection and reciprocates in a proportional way. Noddings claims that care ethics is not a *theory* like utilitarianism or deontological ethics. It does not deal with the abstract and hypothetical but with concrete human relationships. It does not even claim universalizability for all human beings.

Ignoring the fact that Noddings would probably object to a computer simulation given its abstract and hypothetical nature, can care ethics be simulated? I suggest that a good place to start is to build on simulations that already simulate the begetting of offspring. In most of these simulations, offspring are practically the same as the parents, perhaps only with less health or a lower "age" value. There is no enduring link or relationship between the parents and children beyond the passing on of certain "genes," as in the case of evolutionary simulations. However, if we modify such simulations so that the child has serious weaknesses that the parent needs to address, and if we create a unique, enduring link between the two such that parent and child can identify themselves as the "one-caring" and the "cared-for" respectively, that could serve as a basic foundation for care.

For example, it would be the parent's responsibility to collect food in order to feed the child who would otherwise not survive. In order to simulate an awareness of the needs of the other, the parent must know the status of the child in terms of health. To simulate less of a linear rule-dictated behavior and more of an overarching "care" for the child, we can also imagine the parent behaving differently depending on the seriousness and urgency of the needs of the child. For example, the parent might collect food at a pace of 1 step/tick when it knows that her child has a good health of 50 units. But once the parent knows that her child's health has dropped dangerously low to 10 units, the parent might consider various options that she would not normally do: collect food at a pace of 3 steps/tick at the risk of exhaustion, explore a more dangerous part of the map for the sake of better food, etc., all with one goal in mind: to restore the health of her child. Interesting mass dynamics might be observed in crisis situations where many children start suffering from low health (e.g. famine, spread of disease among infants, etc.).

The reciprocity of care can also be simulated. When the parent reaches a certain age in the simulation, she could acquire handicaps and weaknesses. By this time, the child would be a strong adult and would be in a position to care for the aging parent. The roles of the "one-caring" and the "cared-for" will be reversed. This is in fact how it works in many traditional societies where children serve as the "insurance" of parents in their old age. After the caring relationship between parents and children is properly established and configured in the simulation, this can serve as the pattern for caring relationships between siblings, relatives and non-relatives.

What has been mentioned so far is the procedural part of caring. But if we want to be more faithful to what caring means to Noddings, then we would have to deal with the affections and emotions which add a deeper layer of complexity. The "one-caring" needs to be *engrossed* and perhaps even *sad* about the weaknesses and problems of the "cared-for." Meanwhile, the "cared-for" needs to know that the "one-caring" feels this way and that the caring acts are not perfunctory. There are many models proposed for the computer simulation of emotion, some of them based on actual psychological theories (Bourgais, Taillandier, Vercouter, & Adam, 2018). Whether any of these emotion models will suffice to simulate a caring relationship remains to be seen. But it seems that an emotional component is an essential requirement to genuinely simulate care ethics.

Virtue Ethics

Virtue ethics looks at the positive qualities (virtues) and negative qualities (vices) of persons that lead to habitual actions and behavior. It traces its origins to Aristotle's *Nicomachean Ethics* and experienced a revival in the 20th century through the work of Alasdair MacIntyre (MacIntyre, 1981). Perhaps the greatest advantage of virtue ethics is that it is essentially "agent-based." It looks primarily at the person before looking at the person's actions.

Though no author explicitly refers to a computer simulation of virtue ethics, Coelho et al. imply it. They talk about designing an intelligent agent with character and virtues, where "agency and character [virtue is a character trait] merge together and are responsible for all the behaviours generated" (Coelho, da Rocha Costa, & Trigo, 2014, p. 22). In order to do this, they designed an agent that operates a stochastic game in its moral decision-making process, namely, "a partially observable Markov decision process or POMDP" (Coelho et al., 2014, p. 24). Without going into the details of their work, I think the idea of employing stochastics and probability in a virtue ethics simulation will be useful. When we say that a person is just or possesses the virtue of justice, we do not mean that the person does just actions *all* the time, though that person might be expected to do just actions *most* of the time. In simulation terms, an agent might have a justice value of 70%, which means we can expect the agent to perform just acts in about 70% of cases where such acts could apply.

Coelho et al. admit that "it is not easy to design an agent to be gracious, merciful or respectful" (Coelho et al., 2014, p. 22). I add that the success of simulating virtuous agents will depend on their capacities in the virtual world. It is perhaps not so easy to simulate virtues and vices when agents can only eat, move, and reproduce. However, in some simulations such as the classic *Sugarscape* of Joshua Epstein and Robert Axtell, agents can also possess wealth, trade with each other, and come into conflict (Epstein & Axtell, 1996). Such a world would be more conducive for virtues and vices. For example, let us say that when two agents conduct a trade of different resources between them, there is a small probability for an opportunity to "cheat" or "steal" to arise, i.e. an opportunity to take resources illicitly from the other agent. When this opening comes up, a just agent might have a 70% chance of declining this opportunity to cheat, while an unjust agent might only have a 10% chance of "resisting the temptation." We can imagine that as the unjust agent experiences the thrill and reward of cheating, its vice of injustice strengthens, decreasing its justice level to 8%. On the other hand, the just agent also increases its justice when it is able to decline the cheating opportunity, perhaps to 72%.

An additional mechanism is the probability of being found out and punished (in the case of the cheater) or praised (in the case of the just agent). Being punished might teach the cheater a lesson and discourage it from cheating again in the future (increasing its justice level to 12%). Being praised might encourage the just agent to become even more honest

(raising its justice level to 75%). All the dynamics mentioned can easily be simulated since they only involve simple probabilities.

I can also offer a more abstract approach for the simulation of virtue ethics. Let us assume that agents tend to find themselves in certain situations represented by a mathematical function. Each situation can be addressed with an abstract virtue A. An agent will perform gradient descent *n*-number of steps on the situation-function, with *n* determined by the level of their virtue A. The closer the agent comes to a local minimum of the situation-function, the more it can be said that the agent has addressed the situation "virtuously." If it reaches the global minimum, then the agent can be said to have acted in the most perfect way possible given the situation. Conversely, we could talk about gradient ascent and maxima for vices. Reaching either a minimum or maximum of the function can be bound with certain rewards or punishments for the agent. Situation-functions can resemble each other in various ways or can mutate. Some situation-functions might be "tougher" than others, requiring a greater degree of virtue to "solve," i.e. to find a minimum.

The disadvantage of such an abstract approach is that it is not apparent what situation, virtue, or vice from real life is being represented, unlike in the previous cheating example. On the other hand, the advantage is that a situation-function could represent practically any situation in human life, such as "buying a car (requiring prudence)," "confronting a bully (requiring courage)," etc.

Whether we choose a more concrete or abstract approach, if we want to accurately portray virtue ethics then we need to account for emotions just like in care ethics. In traditional virtue ethics, a virtue is considered a virtue if it allows the higher rational part of the agent to control and direct the lower instinctive and emotional part which can often *resist* this control (Aquinas, 2010, pp. 18-19). Emotions need to be simulated to more faithfully depict virtue ethics. Furthermore, in the cheating example above, I also mentioned the possibility of being punished or praised by others which is a social dimension to virtue. A virtue (or vice) can flourish if society at large praises and rewards those who have it. So a system of social reputation needs to be introduced. These emotional and social components will be reiterated in the next and last section when we introduce the PECS reference model for simulation.

To conclude, it is not true, as Mascaro et al. have stated, that natural language in AI is required to simulate other ethical theories besides act utilitarianism. In fact, rule utilitarianism could already be applied to their simulation simply by using a different kind of perspective for assessment; deontological ethics can be simulated using the technique of a "simulation within a simulation" or second-order simulation; the basic mechanism for care ethics can be built on top of simulations that involve parents and children; and virtue ethics can be simulated simply with probabilities or more abstractly with mathematical functions and a gradient descent algorithm. The recurring challenge is the inclusion of emotions, which is needed in care ethics and virtue ethics and to a

certain degree also in utilitarianism. However, there are already emotion models for simulation that can be explored (Bourgais et al., 2018). So far, we have not encountered any insurmountable barriers to the computer simulation of ethical theories. In the next section, I point out the compatibility of virtue ethics with a simulation model that has already been proposed, called PECS. This is a precursory step to attempting the technical implementation of a computer simulation of virtue ethics.

Virtue Ethics and the PECS Reference Model for Simulation

The PECS Reference Model was introduced by Bernd Schmidt and Christoph Urban for the simulation of human behavior in a social environment. It stands for **P**hysical Conditions, **E**motional State, **C**ognitive Capabilities, and **S**ocial Status (Schmidt, 2000, p. 1). It was proposed as an alternative to the popular BDI (Belief, Desire, Intention) model. BDI is a good framework for the rational decision-making process but does not account for emotions and common social behaviors such as communication and learning. Schmidt and Urban claim that to more accurately model human behavior, these components should be included. However, they only provide concepts and guidelines for such a model and not a technical implementation. Based on the literature, PECS has definitely not replaced BDI and it has not received any enduring support from the ABM community. Nevertheless, I think it is naturally compatible with virtue ethics and should be used as the foundation for a computer simulation of virtue ethics.

As was mentioned above, in traditional virtue ethics, a virtue is described as the higher rational part controlling and guiding the lower instinctive and emotional parts of the soul which may *resist* the higher part. This dichotomy corresponds to the two kinds of behavior in PECS: "deliberative behavior" and "reactive behavior," with the latter including "drive-controlled behavior" and "emotionally controlled behavior" (Schmidt, 2000, p. 1). Presumably, "deliberative behavior" comes from the cognitive component of the agent, whereas "reactive behavior" comes from the physical and emotional components. According to Schmidt and Urban, there must be a constant interaction between these components.

In addition, virtues do not arise out of thin air. They are learned from others. A child usually learns them first from parents and elders, and then later on from peers and famous "exemplars."[5] As Aristotle says, "it is not unimportant how we are habituated from our early days; indeed it makes a huge difference – or rather all the difference" (Aristotle, 2000, p. 24). So virtues (and vices) should be able to be "passed on" from one agent to another. As mentioned in the preceding section, virtues (or even vices) can also thrive if they are praised by a particular community. If courage is a highly praised virtue in society, then an agent who is especially keen on social praise will have a greater inclination to be courageous. In short, agents are encouraged towards certain behaviors

[5] For a discussion of the importance of moral exemplars, see *Exemplarist Moral Theory* (Zagzebski, 2017).

because of social influence. All these elements of virtue ethics would fall under the social component of the PECS model.

To provide an example, temperance is the virtue of moderation in matters of physical desire such as food, drink, and sex (Aquinas, 2005, p. 119). We can imagine an agent with a weakness for food who eats more food than everyone else, perhaps 3 units of food instead of the normal 2. This physical drive is genetic, i.e. it is programmed into the agent. Let us say that this is compounded by an emotional response: when the agent is unable to regularly eat 3 units of food, the agent gets "angry" with an irrational proneness (probability) to attack one of its neighbors. This would lead to serious punishment and negative consequences for the agent. However, if the agent has the virtue of temperance, the virtue would have the probability of curtailing these weaknesses either by addressing the physical weakness (it makes the agent eat 2 instead of 3 units of food) or the emotional weakness (it prevents the anger from arising when the agent is hungry). Though on the outside the agent seems to act like everyone else, the agent is more virtuous because it actively practices a virtue that regulates its imbalance. If we imagine a society that praises the virtue of temperance, then this could encourage the agent to increase its level of temperance even more depending on how much the agent is receptive to social influence. This is a relatively simple example, but it touches on all the components of the PECS model.

To conclude, there already exists a reference model for social simulation that is conducive for simulating virtue ethics. As its authors state, "it is a fundamental conviction of the PECS research program that an understanding of human behaviour can be achieved only if all 4 aspects and their interaction are taken into account" (Schmidt, 2000, p. 20). Virtue ethics, in its traditional form, also requires all four aspects and their interaction to be taken into account. What remains is to attempt a computer simulation of virtue ethics using the PECS model as its foundation.

Conclusion

It is possible to do computer simulations of ethical theories with ABM. Though there are challenges involved, there are no insurmountable obstacles to such an endeavor. I hope that this paper provides a starting platform for philosophers to use computer simulations just as many social scientists are currently doing. Computer simulations provide the opportunity to conduct virtual experiments impossible in real life due to practical or ethical considerations. They can be considered "thought experiments" with greater degrees of detail and sophistication than what can ever be done with words. A computer simulation can provoke a deeper understanding and appreciation of an ethical theory as its unique aspects are hammered out in the programming process, or as its consequences are observed in visual simulation. If the simulation is expertly constructed, it might even contribute to defending an ethical theory as being universally valid for human experience, real and imagined.

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Hashgraph the Future of Decentralized Technology and the End of Blockchain

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Abstract

Hashgraph is data structure and consensus algorithm that is fast, with a very high throughput and low consensus latency, secure because of the asynchronous byzantine fault tolerant and fair due to the fairness of access, ordering, and timestamps. These properties enable new decentralized applications such as a stock market, improved collaborative applications, games, and auctions. Hashgraph is a new consensus protocol that has garnered attention lately by being projected as a technology that will make blockchains obsolete. Hashgraph currently scales only in the number of transactions processed but does not scale with the number of nodes in the network. Hashgraph will face the same issues that other public blockchains are facing today and may not be able to maintain its security and performance. In fact, scalability is still an open problem for public blockchains.

Keywords: Byzantine fault tolerance, latency, fair, fairness, hashgraph, blockchain, Swirlds

1. Introduction

The hashgraph is a distributed data structure that maintains a growing list of data among a large amount of network peers. It was first proposed in a white paper by Leemon Baird titled "The Swirlds Hashgraph Consensus Algorithm: Fair, Fast, Byzantine Fault Tolerance". Hashgraph is a new consensus alternative to the blockchain. It uses a gossip protocol that works in the following manner: Every node in Hashgraph can spread signed information (called events) on newly-created transactions and transactions received from others, to its randomly chosen neighbors. These neighbors will aggregate received events with information received from other nodes into a new event, and then send it on to other randomly chosen neighbors. This process continues until all the nodes are aware of the information created or received at the beginning. Due to the rapid convergence property of the gossip protocol, every piece of new information can reach each node in the network in a fast manner. The history of the gossip protocol can be illustrated by a directed graph, i.e., each node maintains a graph representing sequences of forwarders/witnesses for each transaction. In the ideal case, all the nodes have the

same view of all transactions and their witnesses. Further, by performing virtual voting, each node can determine if a transaction is valid based on whether it has over two-thirds of nodes in the network as witnesses. Note that Hashgraph runs in the Byzantine setting, where the assumption is that less than a third of nodes are Byzantine (nodes that can behave badly by forging, delaying, replaying and dropping incoming/outgoing messages). Hashgraph is a new approach that greatly differs to other interpretations of the distributed consensus and looks to provide an upgrade to the current systems of distributed ledger technology (DLT). Hashgraph can resolve today's scaling and security issues, while also pushing the use of distributed consensus applications into new areas.Essentially, Hashgraph is a data structure and consensus algorithm that is faster, fairer, and more secure than blockchain. It uses two special techniques in order to outperform the blockchain. These include: Gossip about Gossip and Virtual Voting.

Gossip about Gossip involves attaching a small additional amount of information to a pair of hashes (Gossip) that contain the last two people talked to. By doing this, a Hashgraph can be built and updated whenever additional information is gossiped, on each node. When the Hashgraph is ready, we are also aware of the information that each node has and exactly when they knew it. As a result, it becomes straightforward to know how a node would vote and this data can be used as an input to the voting algorithm and to find whichever transactions have reached consensus quickly

2. Hashgraph Consensus

Hashgraph consensus is an algorithm that operates on a list of events contained within a hashgraph data structure and maintains consensus over the correct chronological order of the events among an arbitrary number of participating nodes. Use cases can be found in any distributed system that benefits from maintaining a consensus among the participants over the global state of the system and the order of state changes applied to it. Good examples are log replication, distributed ledgers, shared state machines, etc. The algorithm is based on the following core concepts that together provide the properties listed further below:

- Famous Witnesses
- Strongly Seeing
- Gossip about gossip
- Virtual voting

3. Has Blockchain been surpassed by Hashgraph?

Blockchain technology operates as reliable digital ledger that can be used to record financial transactions, ownership, and almost everything of value. Any information held on a blockchain is shared across its existing network and is consistently updated and also incorruptible. This system ensures that data is not stored in any individual location, and that the blockchain cannot be controlled by any single entity. Hashgraph is a

consensus algorithm which has many benefits over Blockchain. It is a new distributed ledger technology which is around fifty thousand times faster than Blockchain, more efficient, more cost-effective, safer and mathematically fairer. Importantly, it does not require significant computation and energy consumption, so it is efficient and sustainable. Blockchain was born out of the 2008 financial collapse and ever since it has been at the forefront of distributed, peer-to-peer transactions. But currently it is limited to 7 transactions per second and a miner can choose the order for which transactions occur in a block, which can delay orders by placing them in future blocks, or even prevent them from entering the system. However, the Hashgraph consensus time stamping prevents an individual from affecting the consensus order of transactions. Hashgraph consensus uses a gossip protocol. This means that a member such as Alice will choose another member at random, such as Bob, and then Alice will tell Bob all of the information she knows so far. Alice then repeats with a different random member. Bob repeatedly does the same, and all other members do the same. In this way, if a single member becomes aware of new information, it will spread exponentially fast through the community until every member is aware of it.

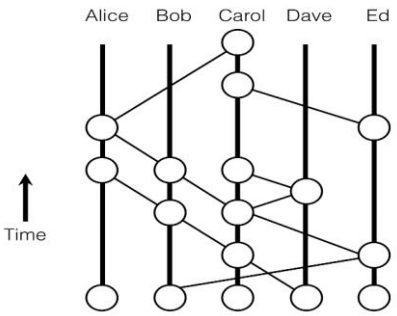

Figure.

Security is also a key issue. With Blockchain there is only an increased possibility of consensus, and when a consensus is not reached forks occurs such as the recent Bitcoin Gold and upcoming Segwit2x forks. With Hashgraph's Byzantine security, a consensus will be reached every time. Also, in hashgraph, every container is used and none are discarded, so this eliminates the problem of stale blocks forming. The end result, Hashgraph is like Blockchain on steroids. It will allow faster, cheaper, safe and more efficient trading of cryptocurrency. If Blockchain had the traditional heavyweights of the financial world quaking in their boots, then Hashgraph will make them a gibbering mess on the floor!

4. Comparison with Blockchain

Similar to systems based on blockchain technology, hashgraph provides desired properties that makes common issues like double spending impossible.

Table 1.

	Bitcoin Blockchain	Hashgraph
Fair	No	Yes
Low Computation	No	Yes
Byzantine fault tolerant	No	Yes
Distributed Trust	Yes	Yes
Solves double spending	Yes	Yes
Mining required	Yes	No

Let's analyze the three claims put forward by Hashgraph.

1) Fast. Hashgraph is fast, as it uses the gossip protocol to spread messages to the network and also performs some optimization of the gossiped messages to reduce the communication overhead. The gossip-about-gossip also yields a consensus protocol.However, there is another reason why Hashgraph is fast: it currently works in a permissioned setting. "At this time, Hashgraph is only deployed in private, permissioned-based networks" —— Hashgraph Team on Telegram. Below, we discuss the difference between permissioned and non-permissioned networks. The difference is crucial as it has a direct impact on the throughput of the consensus solution. In a non-permissioned setting (aka public blockchain) like in Bitcoin/Ethereum, the nodes participating in the consensus protocol are not known beforehand and untrusted since any node is allowed to join or leave the network at will. Moreover, the consensus mechanisms for such a setup have to account for maliciousness, particularly Sybil attacks where a single user generates multiple entities to influence the consensus process and for instance, mounts double spend attacks. Solving these issues in a non-permissioned setting affects the overall throughput.

On the other hand, in private (permissioned) distributed ledgers, identities of all nodes are known beforehand and the network is not open to an arbitrary participant. The prior knowledge of the identities of the participating nodes provides a natural protection against Sybil attacks and makes it easier to reach consensus. This means that no Sybil resistance mechanism needs to be put in place and hence the throughput can be increased dramatically (when compared to public blockchains). As Hashgraph is currently a private distributed ledger, its throughput should be compared with the likes of other private blockchains, e.g., IBM HyperLedger Fabric (700 transactions per second) or Red Belly (400,000 transactions per second). Its throughput should not be compared with public blockchains like Bitcoin or Ethereum (10 transactions per second) as it is equivalent to comparing apples with oranges. Currently, Hashgraph has yet to release concrete technical details for its deployment as a public ledger.

2) Fair. Hashgraph also provides fairness via consensus time stamping. This means that if one transaction reaches two-thirds of the network ahead of other transactions, it is considered to be the first. It is a relatively fair system, as two-thirds of the network are witnesses and it is difficult for a majority of them to make unfair decisions. However, Hashgraph is based on the gossip protocol and this means that when a node chooses its successors uniformly at random, there is some probability (e.g., one-third, if the node's neighbors are chosen globally and uniformly at random) that all the chosen nodes may be Byzantine or malicious. These malicious successors can stop passing the transaction to the next group of nodes, thereby preventing the transaction from reaching two-thirds of the network which would result in an unfair outcome for the honest creator. In addition, trying to ensure that every honest node is connected to some honest nodes, and that every message can be transmitted to other honest nodes without being stopped by intermediate Byzantine nodes, is an open problem in itself. While this is currently not an issue given the private nature of Hashgraph, this will be a hurdle to overcome when releasing a public distributed ledger.

3) Secure. Hashgraph is an asynchronous BFT, but it is not deterministic. In Fischer et al. (1985) it was shown that in asynchronous systems, deterministic consensus protocols are impossible even in the simple case of only one faulty node. A consensus protocol can be either non-deterministic asynchronous or deterministic non-completely asynchronous in the Byzantine setting. For deterministic protocols, all honest nodes reach consensus by round r for some a priori known constant r. For non-deterministic or probabilistic protocols, the probability that an honest node is undecided after r rounds approaches zero as r approaches infinity. For synchronous protocols, roughly speaking, messages are guaranteed to be delivered after a certain bound Δ, but the asynchronous protocols don't have such a bound.

Hashgraph is a non-deterministic asynchronous protocol by adding randomness. The compromise is that the consensus protocol will terminate eventually but there is uncertainty as to when termination will occur. In its current design, Hashgraph employs coin toss (i.e., middle bit of a signature) for nodes to make decisions when there is no progress in the consensus protocol. Therefore, there is non-zero probability of all honest nodes having the same value after numerous rounds of coin toss. Eventually all the honest nodes will become unanimous. However, if all the Byzantine nodes try to disrupt the protocol by manipulating the gossip protocol as detailed in point 2 above, the effectiveness and efficiency of this coin toss approach becomes questionable, as it may take numerous rounds to reach consensus.

Conclusion

Hashgraph is an interesting consensus protocol that has been shown to yield high throughput in a private and static setting. Hashgraph is fast, fair, and secure within the permissioned setting it currently operates in. However, if and when used in a public setting, Hashgraph will face the same issues that other public blockchains are facing

today and may not be able to maintain its security and performance. In fact, scalability is still an open problem for public blockchains. It is interesting to see new solutions being proposed by the community. For instance, Ethereum uses PoS for their Casper protocol, NEO employs dBFT, EOS has a dPoS-based solution, and Zilliqa implements sharding. All these solutions have their own benefits and weaknesses as there is no silver bullet to solve the scalability problem and there has never been one for many scientific problems. Another important question is what does a scalable solution actually mean? Does this mean that the solution is scalable in the number of users or in the number of transactions, or in the size of the network? If a P2P network is capable of processing thousands of transactions, can we call the solution scalable? If so, what happens when the network doubles its size—— can the throughput be maintained? In fact, a solution that is scalable in a single dimension may not be well-suited for a use case that requires scaling in a different dimension. Hashgraph currently scales only in the number of transactions processed but does not scale with the number of nodes in the network. Zilliqa for instance scales with the number of nodes in the network. So, let us all appreciate the underlying technology in Hashgraph but not with closed or blinded eyes. And while we appreciate Hashgraph, we should also appreciate blockchains which have paved way to the likes of Hashgraph in just the same way, they have paved the way for Ethereum, EoS, NEO, Zilliqa and many others. Hashgraph is proven to be fully asynchronous Byzantine. This means it makes no assumptions about how fast messages are passed over the internet and this makes it resilient against DDoS attacks, botnets, and firewalls.

The Hashgraph algorithm works without needing to use the Proof of Work or Leader systems, and can also deliver low-costs and high performance levels without a single point of failure. Hashgraph does away with the need for extensive computation and energy consumption and improves on the performance statistics of the Bitcoin network. Bitcoin operates at a maximum of 7 transactions per second. While Hashgraph is only limited in relation to bandwidth and allows for over 250,000 transactions per second.

In addition to this, Hashgraph also allows more a fairer system of operations as currently, miners can choose the order for which transactions occur in a block, and can even delay orders by moving them into future blocks, or even stop them from entering the system if necessary. Hashgraph utilizes consensus time stamping and prevents any individual from changing the consensus order of transactions by denying the ability to manipulate the order of transactions.

Despite its obvious benefits, Hashgraph has some way to go before it can boast of the network effects enjoyed by both Bitcoin and Ethereum. However, in the ever evolving world of blockchain technology it seems we are on the cusp of the next stage of evolution.

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Analysis of Students' Factors Influencing the Integration of E-Learning in Higher Education. Case Study:University of Tetovo

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Abstract

E-Learning is an Important tool for delivery, interaction, and facilitation of both teaching and learning processes in higher education. The purpose of this paper is the investigation of students' attitudes about the use of ICT and integration of e-learning at the University of Tetovo. This study also examines the factors contributing to students' attitudes towards E-Learning as well as identifying the important factors to its successful integration. The conceptual research framework of e-learning integration, which is used in the analysis, is based on the technology acceptance model (TAM). The research developed an extended TAM model (Technology Acceptance Model for E-learning) for predicting the intention to integrate E-Learning using the constructs of the TAM. Statistical analysis was conducted to assess student attitudes towards integrationof e-learning, and to analyses the relationships between their attitudes and their demographic characteristics, Perception about ICT,ICT experience and ICT Competence that predict the integration of e-learning. Questionnaire was used to collect data from a sample of 314 undergraduate students from different program studies. Statistical techniques are used for the analyses of data. Factor analysis was used to validate the instrument, however; the partial least square method was used to test the model for the study, moreover; stepwise regression analysis were used to test the hypotheses of the study. The findings indicate that students have an important role in prediction of the integration of E-Learning in University of Tetovo. The reported findings might be of interest to institution, academics administrators, and decision-makers involved in planning, developing and implementation of e-learning in University of Tetovo and similar universities in developing countries.

Keywords: Atittude, TAM, ICT competence, ICT experience, ICT perception, Prediction

Introduction

The role of information, communication and technologies (ICT) in learning and teaching process is becoming more and more important tool. One of the most significant developments in the use of information technology in universities in the last decade has been the integration and use of e-learning systems to support the processes of teaching and learning. E-Learning is a concept derived from the use of information and communication technologies (ICTs) to revise and transform traditional teaching and learning models and practices has evolved in the past decade(OECD, 2005). Numerous researchers have stated that the role of student in the process of integration technology in the teaching and learning process has been crucial (Chen, 2010; Park, 2009; Teo & van Schaik, 2009; Wong & Teo, 2009). Student characteristics are regarded as a critical success factor in e-learning in developing countries(Bhuasiri et al., 2012).These characteristics include computer self-efficacy, Internet self-efficacy, computer experience, Internet experience, computer anxiety, and attitudes toward e-learning. Students' attitudes towards E-Learning are dependent on access to ICT as well as the perception of the usefulness of E-Learning in the educational process (Kirkwood & Price, 2005). Students' attitudes are also influenced by their previous experience and skills with ICT and E-Learning. Student attitudes towards ICT and integration of e-learning at the University of Tetovo as one of public university in Macedonia where the teaching and learning language is Albanian language have not been investigated before. Also, this study investigates the factors that influencing students' attitudes about the integration of e-learning in learning and teaching process. Consequently, this paper aimed to assess the perception of students' towards integrating e-learning into teaching and learning at University of Tetovo. In this study is used the Technology Acceptance Model (TAM), which is a model widely used in the studies about the acceptance of technology(Davis, 1993).This study proposes the use of an extended TAM model, which determines perception about technology, technology compentence and technology experience are primary factors influencing students' attitude and the intention to adopt the technology.Furthermore, knowing the students' attitudes about ICT and integration of the e-learning,and understanding the factors that influence students' attitudes about integration of the e-learning can help academic administrators and managers to create mechanisms for attracting more students to adopt this learning environment.

Research Model and Hypothesis

The objective of this research was to investigate the factors that influence the student's attitudes towards using ICT and integration of e-learning system at the University of Tetovo. However, for the purpose of model development for this research, the TAM model will be expanded including these external variables: Perception about ICT **(perceived** usefulness of technology, perceived ease of use of technology), ICT Experience **(technology usage and experience),** and ICT Competence **(level of knowledge and skills about technology),** which all have proven to be important

factors that influence lecturers behavioral intentions toward adopting a new system. The research model is presented in Figure (2).

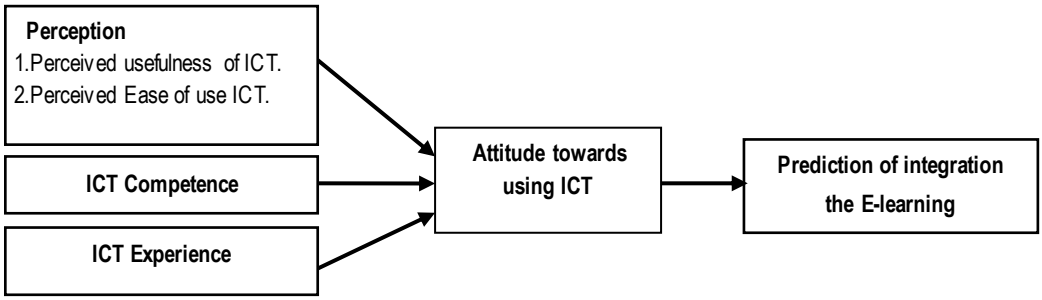

Figure 2: Research Model

The study is divided into two phases. The first stage involved taking the variable Attitude as the dependent variable and all other variables as the independent variables (Perception, Competence and Experience).

H1.Students Perceptions about ICT have a positive influence ahead Attitude towards using ICT .

H2.Students ICT Competence have a positive influence ahead Attitude towards using ICT.

H3.Students ICT Experience has a positive influence ahead Attitude towards using ICT.

The second stage involved taking the variable E-learning Prediction (shortened for Prediction of Adoption of E-learning) as the dependent variable and all other variables as the independent variables.

H4.The perception of students on the technology has a positive influence ahead the Prediction of e-learning.

H5. Students ICT Competence has a positive influence ahead the Prediction of integration e-learning.

H6. Students ICT Experience has a positive influence ahead the Prediction of integration e-learning.

H7.Students Attitudes towards ICT has a positive influence ahead the Prediction of integration e-learning.

Research Methodology

For this study was used a questionnaire to obtained data across six sections consisting of: 1) demographiccharacteristics of students ; 2)Perception abouttechnology (perceived usefulness and perceived ease of use)(14 questions) ;3) ICT Competence (level of knowledge and skills about technology) (7 questions)4) ICT Experience (Technology usage and experience)(6 questions); 5) Attitude towards ICT in teaching

and learning process (6 questions); and 6) prediction of E-Learning(12 questions).Data was collected from 314 undergraduate students of different faculty at University of Tetovo. Data for this research was collected through a survey instrument and analysed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize and describe the data collected from the respondents. Furthermore, factor analysis was also performed to identify key factors that are likely to influence integration.In addition, The reliability of the quantitative data in this study was determined by finding Cronbach's Alpha . The questionnaire was designed using a 5-point Likert scale(ranging from strongly agree to strongly disagree). Finally, Pearson Product Moment correlations were used to examine the relationships between the variables that were measured on the interval scale.

Data Analysis and Results

Data was analysed using Statistical Package for Social Science (SPSS) software. Descriptive statistics such as median, frequency, and percentage are used for analysis. Demographic characteristics of studetns are given in Table 1.

Charachteristics	Category	Frequency & Percentage in the Study	
		N	%
Gender	Male	126	40.1%
	Female	188	59.9%
Study program	Informatics	72	23.9
	Mathematics	68	21.7
	Physics	14	4.5
	Chemistry	44	14.0
	Biology	18	5.73
	Marketing and Management	13	4.13
	Economy and Business	40	12.74
	Finance and accounting	45	14.3
Year of study	first	89	28.3
	second	81	25.8
	third	93	29.6
	forth	51	16.2
Use E-learning as Learning Tool	Yes	117	37.3
	No	197	62.7
Total No. of students		314	100

Table1.*students' demographic characteristics*

Also the descriptive statistics showed that the majority of participants indicate positive responses to the constructs that are measured in this study (See Table 2). All means were above midpoint and the standard deviations range from 3.58 and 8.25.

Factors	N. of Question	Min	Max	Mean	St.d dev.
PERCEPTION about ICT	14	24	70	53.0288	8.25
ICT COMPETENCE	5	4	25	16.6997	3.58
ICT EXPERIENCE	7	7	34	16.3671	5.75
ATTITUDE towards ICT	6	4	30	21.7604	4.94
PREDICTION of E-Learning	11	9	54	37.8814	7.00

Table 2: Descriptive Statistics of the constructs

The reliability analysis measured the internal validity and consistency of items used for each construct. Calculating Cronbach's alpha coefficient tested the factor reliability. Recommended that a Cronbach alpha value of 0.7 and greater is acceptable(Dunn-Ranking,2004). Cronbach's alpha values for all factors are above 0.70 (see Table 3) indicating that all measures employed in this study demonstrate a satisfactory internal consistency. Therefore, the survey is considered a reliable measurement instrument.

Construct	Cronbach Alpha	Number of Items
PERCEPTION about ICT	0.833	14
ICT COPETENCE	0.668	5
ICT EXPERIENCE	0.889	7
ATTITUDE towards ICT	0.829	6
PREDICTION of integration E-Learning	0.817	11

Table 3: Cronbach*Alpha Coefficients for Constructs with Multiple Items*

In this study were used the Pearson correlation coefficients to measure the relationships between the variables. Correlation analysis answers the question if there exists association or correlation between the two (or more) variables and to what degree. The correlation coefficients were interpreted by descriptors, negligible = 0.00 to 0.09; low =0.10 to 0.29; moderate = 0.30 to 0.49; substantial =0.50 to 0.69; very strong = 0.70 to 1.00 (Davis,1971). The correlation matrix is presented in Table 4.

	PERCEPTION about ICT	ICT COMPETENCE	ICTEXPERIENCE	ATTITUDE towards ICT	PREDICTION of integration E-L
PERCEPTION about ICT					
ICT COMPETENCE	.407				
ICT EXPERIENCE	.379	.314			
ATTITUDE towards ICT	.506	.410	.312		
PREDICTION of integration E-L	.379	.372	.223	.479	

*Table 4. The correlation matrix of factors (***. Correlation is significant at the 0.01 level (2-tailed)).

For testing hypothesis is used a linear regression analysis that was undertaken using the dependent variables for integration e-learning using the method enter. In the table 5 are summaries the results obtained from testing the research hypotheses. The results confirmed that there was a statistical correlation between the predicted directions of the research model. Overall, all of seven hypotheses were supported by the collected data. After the examination of each of the seven hypotheses was made.

Research Hypothesis	Path	Standardized Path Coefficient (Beta)	t-value	Significance	Results Significance (p)	R^2
H1	P→A	.496	10.100	.000	Supported	.246
H2	E→A	.304	5.643	.000	Supported	.093
H3	C→A	.410	7.950	.000	Supported	.168
H4	P→PEL	.371	7.037	.000	Supported	.137
H5	E→PEL	.204	3.674	.000	Supported	.042
H6	C→PEL	.350	6.597	.000	Supported	.123
H7	A→PEL	.453	8.955	.000	Supported	.205

Table 5: Summary of the Hypothesis Testing

To determine a goodness-of-fit measure which determines how well the statistical model fits the set of observations is used the linear regression. The analysis of the model used in this study is examined the goodness of fit among the Students with the analysis indicating that the model accounted for approximately 25.1 % of the variation (R^2= .251).

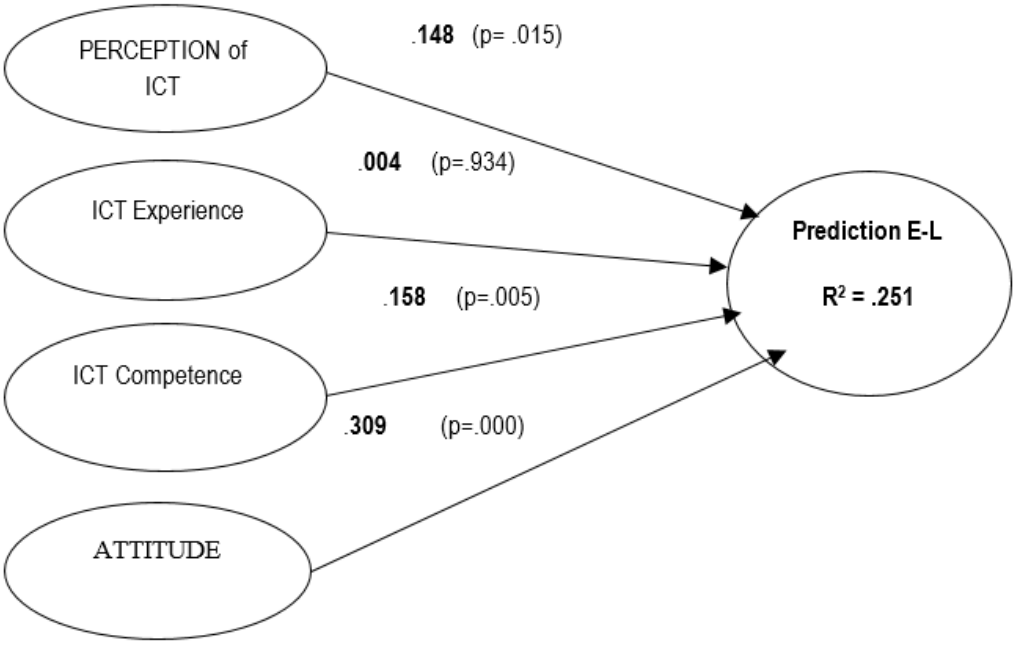

Figure 4: Results of Beta values and results for Students R^2

The analysis of the model using SEM and the SPSS software for the linear regression indicated that the model explains approximately 25% of the variance in the prediction or intention to use E-Learning from the students (R^2 = 25.1%). The results of our model for the goodness-of-fit for the model are different to the findings of others researchers investigating, for instance,in (Park, 2009) the percentage for the goodness-of-fit was (R^2 = 66%), and in (Mazen et al, 2013) the percentage for the goodness-of-fit was (R^2 = 59%).

Findings and Discussion

The purpose of this study was to analyze the attitudes of students towards technologies in the learning process and the factors that influence their decisions to adopt and integrate these technologies into teaching process.The aim of the analysis was to determine the degree to which these three variables and include the construct of Attitude, which is considered an intermediate variable influence the Prediction of the integration E-Learning. From the obtained results and based to analysis we can conclude that not all factors added to the expanded TAM model have significant effect on Prediction of the E-Learning.Results show that only the variables of Attitudes, Perception about ICT and ICT Competence had a statistically significant effect on the Prediction of E-L. The findings about factor ICT Experience, show that this factor is not statistically significant that is contrary of the findings of others previous researchers. The analysis as shown in Table 5 indicated that the variable of ICT Experience did not account for a significant amount of the variance in Prediction of integration e-learning

based on goodness-of-fit (ICT Experience R^2 = .042), while a weak correlation was found. Findings from the study demonstrate that there was a statistically significant moderate association between variables ICT Competence and Prediction of integration E-leaning. Thus, it implies that students with knowledge and skills in ICT played a significant role in constructing positive attitudes towards integration of e-learning and means thatstudents whose have skills in ICT and greater level of knowledge about ICT, have more positive intention towards integration of e-learning in the teaching process. Also, results obtained that there was a statistically significant moderate association between variables Perception about ICT(the variable is composed of perceived usefulness of ICT and perceived ease of use of ICT) and Prediction of integration E-leaning. On the other hand, there was a low association between variables ICT Experience and Prediction of the integration of e-learning in teaching and learning process.

Another findings from the analysis is that, the individual factors have a moderate relationship with Attitude, but the three taken together have a substantial association. Attitude itself is moderately associated with E-learning Prediction. The finding of a moderate relationship between positive Attitude towards ICT and prediction of E-Learning is differently to the findings of researchers in other nations examining the relationship between attitude and adoption of E-Learning where the relationship is strong. Therefore, from the analysis and results reported here are consistent with outcomes of similar studies, noting that attitude was a key factor in determining technology adoption (Teo, Lee & Chai, 2008, Teo, 2012). The findings also conform to the proposition of the model, that attitude is the most significant predictor for the intention to adopt a technology (Shin & Kim, 2008).

Conclusion

This study demonstrated the importance of students' Perception about ICT, ICT Experience and ICT Competence for attitudes towards integration E-Learning in teaching process. Greater part of students in this study believed and has positive attitude that using ICT in learning would significantly contribute to the efficacy and effectiveness of their teaching. Findings from this study suggest that students' positive attitude towards ICT and e-learning is essential if University of Tetovo need to successfully transform its education systems from the current classroom face-to-face methods to e-learning. In conclusion can say that students are one of the key stakeholders of education and their attitudes towards using ICT and also their skills, experience and perception about ICThas a significant impact on prediction of integration of e-learning in learning and teaching process. Identification of attitudes and factors influence integration of e-learning would provide useful knowledge for education stakeholders and higher institution which can help in planning and increasing effectiveness of the adoption of e-learning in higher education. The research model and the findings of the study can serve as a model for developing framework and which stockholders and factors to take into consideration for integrating e-leanirng into the teaching process as a learning method

for the students of the University of Tetovo as well and other universities in the developing countries.

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