The Ripple Effect: How Chaos Theory can Transform Education

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ABSTRACT: Background: The education atmosphere in a class could influence students' attitude and their understanding and willingness to collaborate in a class. Chaos has a different meaning for different students and lecturers. Sometimes this same chaos could be the best possible paradigm or teaching strategy to influence students to have a deeper understanding of the work. The use of chaos theory in higher education could allow for a different way in which students view information and how they engage and collaborate in the class. **Focus:** In this research the use of chaos theory in Higher Education Institutions classrooms was researched to be able to answer the following research question: How do students and lecturers perceive the impact of chaos theory on fostering deeper learning and critical thinking in academic settings? **Methodology:** A qualitative research design was followed to determine how students experienced this approach of teaching, and the experience from the lectures who apply this theory and method of teaching in the class. A case study design was followed to discover how the method is implemented in class and students used an open-ended questionnaire to explain their experience. The lecturers involved also filled in an open-ended questionnaire to explain the difference between the normal teaching strategy they used in their classes in relation to the chaos theory. Purposive sampling was used to determine who will be part of the study. Only lecturers who were willing to test the results regarding the chaos theory were asked to take part in the study. **Results and implications:** A paradigm change could contribute to deeper learning. The way lecturers approach this theory in the classroom contributed to a new approach of lecturing to use in the classroom to ensure students gain deeper learning in a different way than before. Students experience the situation differently and from the case study it was clear that lectures and students explain that this method of discovering and exploring need to be develop more in classrooms and students need to get the opportunity to be exposed to this method of lecturing. In the light of this, a recommendation to lecturers will be to explore this method of instruction and allow students to discover information in a different method.

Keywords: Chaos theory, Deeper understanding, Teaching strategies, Students attitude and education atmosphere

1. Introduction

Discussions regarding education often start with words like structured and focused. However new paradigms and new ways of thinking and approaches in education, especially with the focus on Higher Education, become more popular. Different paradigms and different theories need to be implemented to ensure students would be intrigued to come to class and have teaching experience which would support them to have a better understanding of the work. According to Akmansoy and Kartal (2014:510): "chaos theory provides refreshing insights into an educational system that consist of a mechanical world win which many individuals attempt to learn information under whatever philosophy of education is popular at that time". Chaos theory is a framework that studies how small changes in initial conditions can lead to unpredictable and complex outcomes in dynamic systems, emphasizing nonlinearity and sensitivity to initial conditions (Gleick, 1987). In this research a case study to investigate how the method is implemented in class was looked at, and students filled in an open-ended questionnaire to explain their experience. Lecturers were provided with an activity that related to barriers of reflection and the activity was designed to instil chaos in the classroom. The lecturers involved also filled in an open-ended questionnaire to explain the difference between their normal teaching strategy they used in their classes in relation to the chaos theory.

2. Literature Review

Chaotic and confusing scenarios could contribute to a different approach and deeper thinking of students in Higher Education Institutions. With the application of chaos theory random scenarios contribute to a complex analysis and students are offered the opportunity to re-think and change their way of thinking to discover a deeper understanding and meaning of the work (Kayuni, 2010). This theory will contribute to some changes regarding instruction. Traditionally control, order, objective, safe, certain, predictable and one best way would be applied and used in classes and students were bound to these prescriptions. With the application of the chaos theory in class, control is replaced with chaos, order with disorder, objective with subjective, safe with unsafe, certain with uncertain, predictable with unpredictable and one best way with any way. Students learn to form their own point of view and look at situations to be able to answer questions with a deeper understanding and not necessary according to a specific memorandum or prescriptive way of thinking (Kayuni, 2010). Richard Paule added that for lecturers to see students engaging with their studies in this manner, they also need lecturers who

will value critical thinking, and who will model the critical thinking skills that they are trying to develop in the students (Paul, 1993).

Even though chaos theory promotes a different point of view and a different approach than traditional education, it complements the education system which is a social unpredictable system (Khanal, Bento & Tagliabue, 2021). It is very important to emphasise the fact that chaos theory do not represent disorder or chaos in the sense of unplanned and unorganised, however it represents unpredictability and involved complex interactions (Lartey, 2020). Unpredictable human behaviour, especially in education, contribute to the fact that chaos theory could be applied in education because of this theory's discoveries in the field of nonlinear dynamics (Kiel and Elliot, 1996). Learning and thinking are nonlinear processes and lecturers in Higher Education Institutions need to use this theory in the class to obtain contribution and collaboration from students especially from the less successful students in the class (Khanal, Bento & Tagliabue, 2021).

Nonlinearity, feedback, bifurcation, strange attractors, fractals and self-organisation is the six key constructs of the chaos theory according to Lartey (2020). Nonlinearity can be explained by the relationship between variables that are not linear. In education this nonlinearity will be the unpredictability and different viewpoint. This is when students receive a case study with a different effect than the predictable situation. This nonlinearity flow over in the second construct namely feedback. When situations and case studies are unpredictable and nonlinear, students would need to provide feedback on a situation. This also contributes to deeper learning and understanding. The third construct, bifurcations is a sudden change of direction or characteristic or outcome. As such this is when students identify strange patterns or start to approach a problem differently. The fourth constrain is strange attractions which define the boundaries of dynamic systems as these systems progress towards chaos due to their continuous grow. The fifth constrain is fractals which make predictability of long-term outcomes impossible. Students need to work with what they have and will not be able to predict the outcome, which connect to the last construct, namely self-organisation. At this point, students need to communicate the change within a system and allow all parts to react to change and generate a new inner state of form (Lartey, 2020). These constructs speak to what Joseph Ford (cited in David, Smith and Leflore, 2008:8), a physicist at Georgia Institute of Technology, outlined: "chaos, educationally speaking is thinking freed from the shackles of order and predictability, children liberated to explore their every dynamical possibility, resulting in exciting variety richness of ideas and thought, a cornucopia of opportunity."

In conclusion, the application of chaos theory in higher education promotes a paradigm shift from traditional, linear instructional methods towards a more dynamic, non-linear approach that encourages deeper critical thinking and understanding. Chaos theory provides a framework for fostering unpredictable yet productive learning environments. This approach allows students to explore different perspectives, re-think conventional methos and engage in deeper learning by navigating complexity and unpredictability. In this research a change in instruction will be research to see if this could contribute to deeper learning and understanding.

3. Theoretical Framework

Chaos theory as method of instruction were used in this research, and for this reason, chaos theory will also be used to analyse the data of students and lecturers experience of the use of chaos as a method of instruction. Roberston (2020: 01) said as follows: "Chaos theory teaches educators that despite the appearance of chaos on the surface a deeper order can exist. Understanding that order can inform our conversations with each other about teaching as well as our own development as teachers."

From the explanation as mentioned in the literature review from Lartey (2020), the following six points will we used in the data analysis process in order to answer the following research question: How do students and lecturers perceive the impact of chaos theory on fostering deeper learning and critical thinking in academic settings? The six points are as follows: nonlinearity, feedback, bifurcation, strange attractors, fractals and self-organisation. From the data received from students and lecturers the focus will be on the effect of chaos method of instruction. This viewpoint requires an approach in which the data will be organised into themes and will then be compared with the theoretical framework as mentioned above.

4. Method

In this research a qualitative research design was used, to understand how students experience this theory in class. This design is suitable for this specific research, because the data, in the form of words were collected to discover how lecturers and students experience this method of instruction (Busetto, Wick & Gumbinger, 2020). A case study design was followed to discover how the method is implemented in class and students used an

open-ended questionnaire to explain their experience. The focus was on Higher Education Institution classrooms. Purposive sampling was used to determine who will be part of the study. The same module which are lectured on three different campuses were used in the research. First lecturers were asked if they will be willing to take part in the study, where after all the students in those classes were selected. The students and lecturers of final year Education were used in the research. Lecturers were provided specific content to lecture and discuss with students, to make sure all students received the same information. The process was the same on all three campuses:

- Students received a notification reminder to come to class to solve a mystery, and another reminder was sent through the Learning Management System to make them excited and create a build up towards the activity itself.
- Students only received the activity after the discussion in the class. The activity includes scenarios of different barriers in reflection. This is a completely different way of for students to analyse the barriers.
- Students could divide (spontaneously) into groups to complete the activity if they would choose to do so. It was important to allow students to choose their own groups or they could work on their own should they choose to.
- Only once the students completed the activity could they get access to the link to complete an open-ended-questionnaire. This allows all students to first experience the complete activity, before they explain their experience. The questionnaire includes questions regarding the change in the learning process, predictable learning, resilience and adaptability to find out if chaos theory as a method of instruction could contribute to deeper learning.
- Lecturers were also asked to complete a questionnaire after the students completed the activity to get their point of view.

This activity was used to offer a structured way to enhance student engagement and critical thinking, creating opportunities for intellectual growth and innovative learning experience.

5. Data Collection

One hundred and forty-four students took part in the activity in class and had to answer an open-ended questionnaire. Before students had access to the questionnaire, they were asked to provide their consent to the researcher to use the information in the research. The first question was only an introductory question to understand if students are used to very structured lessons or a variety of methods of instructions. The questions that followed were focused on the impact on students regarding the different method of instruction and if deeper learning did take place. Lecturers lecture according to their own teaching strategy which are formed from their own experiences in life. In the same way, different students experience classes and methods of instruction in different ways because they have a different viewpoint in life (Kampen, 2024). Students were asked questions regarding the activity and if they experience something different in the method of instruction? Finaly students were asked to reflect on their experience of the activity and if they could see how they developed deeper learning or something else.

6. Data Analysis

In this research the use of chaos theory in Higher Education Institutions classrooms was researched. As explained earlier the theory was used as a method of instruction. With the analysis of data, it was clear that students answered the question from their own experience but what was very interesting is the fact that they also recalled situation during their Teaching Experience where teachers used chaos theory as method of instruction and provide information regarding those situations as well. Even though this research only focuses on Tertiary Education, the focus was on the Faculty of Education, as such, the researchers would also incorporate those answers which focus on school situations.

With the use of chaos theory as a method of data analysis it was clear with the data that all different parts overlap and connect to each other. Please see Figure 1 below.

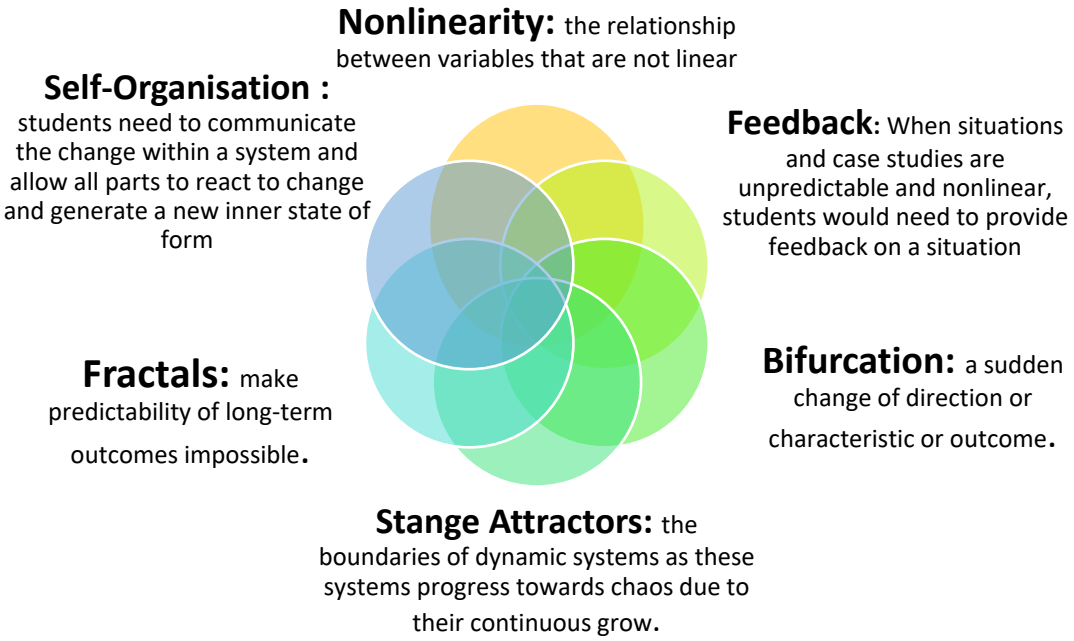

Figure 1: Connection between the different parts of chaos theory

Nonlinearity: During this class, students had to solve a mystery and could only move to the next question if they the correct answer. This was different from the previous classes. Lecturers experienced different behaviours from learners. Lecturer 1 said: "*Some students jumped in and start to do the activity, excited and figure everything out. Others were just sitting there*". This is just an example how methods of instruction have a different effect on learning for different students. Students explained that the atmosphere in a class also contribute to the level of learning. Lecturer 2 explain that because students received more than one chance to try to complete the activity it contributed to the fact that they explored more and started over again if they got something wrong. This could also put emphasis on the fact that students need to develop the confidence to try and answer questions even if they are not hundred percent sure if this is the correct answer.

Students were asked how classrooms foster exploration and discovery or if they prioritize linear, predictable learning. Some of the student participants mention as follows Student 1: "*It is context dependant. Given the difference in teaching approaches by various teachers, the methods used provide different outcome in learning".* Student 4 explains as follows: "*Linear and predictable learning is the most common way of teaching".* Student 18 said the instructor influence how much exploration and discovery could take place in the classroom irrespectively of the content of the work. Student 9 mention the importance of lecturers who teach in the 21st century need to teach their students or learners how to explore and discover. Everything does not need to be predictable. Student 20 mention the following: "*Teaching needs to foster exploration and discovery, teachers need to allow learners to explore and express their thoughts."*

Student 108 explain as follows: "*In my experience, classrooms can be quite diverse in how they approach learning. Some prioritize exploration and discovery, allowing students to engage in project-based learning, hands-on activities, and inquiry-based methods."*

The comment above links a lot to the comment of Student 73 explained as follows: "*Traditionally, many classrooms prioritize linear, predictable learning, focusing on standardized curriculum, lecture-based instruction, and memorization. This approach often limits exploration and discovery, as students are not encouraged to ask open-ended questions, explore topics in-depth, make connections between subjects, or learn from failures and mistakes".*

Lecturers and educators realise that discovery and exploration is very important, especially for deeper understanding and leaning, however it seems as if the linear and predictability of a lesson could be more convenient and comfortable for the lecturers.

Feedback & Bifurcation: This is to see how students' responds to chaotic or non-predictable activities in the classroom. It also shows when students identify critical moments where small instructional approaches can lead

to a significant shift in the instructional approach and led to a significant shift in students' behaviour or understanding. Lecturer 2 explain that this learning unit had to be covered and with this approach as it contributes to some fun in the classroom and students were given the opportunity to discover and try to link the content of the learning unit to real world situations and try to solve how they can apply the content. Lecturer 3 were amazed by the fact that the activity contributed to the students pursuing a line of questioning and displayed curiosity: "*Some students were patient and persistent knowing what the correct answers was and try to complete the assignment with enthusiasm. Others were very hesitant to start and try to look at other groups to see how they complete it and what they discuss. They look quite lost."*

During this activity in the classroom students were asked how they build resilience and adaptability when faced with the inherent uncertainty of the learning process. Student 2 explained that if students are provided with more challenges and difficult activities or tasks, they will develop a tolerance for discomfort. Student 5 said as follows: *"The key is building resilience and adaptability. Building your mental fortitude."* Student 7 mention on a personal level if he/she is confronted with difficult situations activities, the student will re-think and read again and then also start to ask questions.

Student 23 explains students need to be provided the opportunity to practice developing resilience and adaptability: "*By encouraging students to see the challenges as opportunities for growth and learning, they can approach uncertainties with a positive outlook and a willingness to preserve through difficulties."* Student 32 mention that students will develop resilience by working through their challenges and adapting to the learning process. The comment of student 33 connect to the previous comment and mention how students need to be encouraged to step out of their comfort zone and take on challenges. More participants mention the fact that students need to be trained to use problem-solving and develop resilience.

Students were asked how this experience of chaos theory as a method of instruction perhaps influenced their view of learning. Student 6 explain that during the session, while the students were stuck on a problem, another student explained something considering a real situation and showed the comparison, student 6 said as follows: "*This event completely changed my view on the learning because it showed me that importance of real-world connections in understanding abstract concepts*." This comment highlighted the fact that students need to be given some time to grapple with a problem and be comfortable to be uncomfortable. Student 15 explain as follow: "*This experience made me realize the importance of attention to detail and the impact that minor mistakes can have on the overall outcome. This experience reinforced the idea that continuous learning involves not only grasping complex concepts but also paying close attention to the finer details to ensure a comprehensive understanding of a topic."*

Student 29 explain that this method did not influence his/her viewpoint. Student 30 felt the chaos theory left him/her frustrated and tedious and explained that learning was not effective because of the different atmosphere in the class. Student 35 explain as follows: "*It made me more anxious about the content as I had to completely change my perspective of what the topic entails."* Student 52 also mention a negative experience: "*This experience influenced my view of learning by doubting myself."* Student 54 also experience this method negatively: "*This experience also caused me to feel negative towards the learning process because there was a struggle in understanding when it was questioned by a minor event. Nothing made sense."*

Student 43 felt more positive towards this method of instruction and explain: "*This gave me the opportunity to reflect on what went well and what went wrong and therefore it was an avenue of more improvement and growth as a student."* Student 59 mention this method influenced his/her view of learning and the student said that he/she realises that learning can happen through unexpected sources and change his/her viewpoint of the learning process.

Strange Attractors: This is when students look for recurring patters or behaviours and how students gravitate toward chaotic instruction. Lecturer 3 explains that students are normally not participating and engaging in the class and when they received the activity, some groups were very excited and started to solve the mystery and you could see how they became excited about it and shared their different views with the group. Other students kept on looking at other groups as if they were unsure what to do. Those students reacted negatively on the different way of instruction. Lecturer 1 said: "*The activity and instructions contribute to chaos for some students. For other students this was exciting, and they enjoy discovering the answers and took part in group discussions."*

Students were asked when during the activity did, they experience it to be chaotic. Student 3 explain as follows: "*When we started the breakout activity, very few people understood what needed to be done and the lack of context made the questions very difficult and confusing we had no clear expectations of the outcomes."* Student

27 said the activity become chaotic when students began working in groups and discussing their different ideas and there was disagreement within the groups. Student 32 explain that the chaos began just after their received the instructions. Some students in the group wanted to complete the assignment quicker than others. Student 44 explain that the chaos started in the beginning because some of the group members did not understand the activity completely.

Fractals: This makes predictability of long-term outcomes impossible. Students need to work with what they have and will not be able to predict the outcome. As seen in the comments from students under Strange Attractors, there was confusion for a lot of students, and others who merely jumped in and started to see what they could discover.

Self-Organisation: Students could spontaneously form groups and develop unique methods of tackling problems or collaborate to solve some problems. Lecturer 1 explain as follows: "*Personally I think students need to be placed in more situations like this to discover work on a different method than the usual".*

Students were asked how they experience the class environment and the groups, which they could create on their own. Student 15 explain as follows: "*To work in groups come spontaneously but the classroom setup was not ideal."* Student 42 said: "*The seating arrangements were in groups which allow for a seamless interaction."* Student 48 explain that it was difficult when every group were on a different stage of the activity, and you could hear some of the answers before you get to the specific question. Student 51 explain the fact that groups could form spontaneously result in the fact that there were groups which were too big, and some students did not even take part in the activity but just answered the questions while others were searching for the answers. Student 63 explain as follows: "*The classroom environment played a significant role in the chaos. The seating arrangement, with desks pushed together for group work, made it difficult for students to focus on their own discussions without being distracted by neighbouring groups. The noise level escalated quickly, making it hard for anyone to hear or be heard clearly, which further fuelled the disorder".*

7. Results and Implications

From the research and data analysis it is clear that small changes may lead to a significant shift in the learning process. Whit a different method of instruction students' needs to think differently, and deeper learning takes place. This can be seen when the same types of challenges occur across different student groups or individual students show similar patterns in learning. Some students mention the effectiveness of a mix between linear and exploration way of instruction. Especially in a classroom where there are a lot of resources available, teachers need to use it and allow learners to explore and discover, especially in a life science classroom. One participant also explain that teachers sometimes only give activities straight from the textbook which do not support learners to be more creative and explorative, and it do not always link to the real world.

Effective classrooms balance is so important to increase a deeper learning with students. Structure and predictability with flexibility and autonomy, allowing students to explore and discover concepts in a supportive and guided environment, leading to a more engaging and meaningful learning experience.

When students face this different method of instruction, they shift their understanding of learning and view problems from a different point. More respondents mention the fact that the moment confusing topics are linked to real-world-situations or examples, it changes their viewpoint to the situation and at the end help them to resolve the situation or problem. Some students did not have a clear sense of the expectations that were set for them, causing them to feel lost, in discomfort and confused. This contribute to the fact that students need to be taught to receive different methods of instruction. In the same activity other students felt that the open opportunity allowed them to discover. Both groups had the same amount of chaos and unpredictability in front of them and their approach to the activity is what set apart how the learning took place.

8. Conclusion

From this case study it was clear that both lectures and students' attitude towards a different method of instruction was very positive. With the introduction to lecturers, they hesitated and were cautious about if it will work, but they were more than willing to take part and looked forward to discovering the outcome. When the introduction was made to students, because of the unusual introduction to the class, students were very curios and their positive attitude towards this method of instruction contributed to the fact that they wanted to explore this method. Especially in the 21st century, more contemporary approaches and method of instruction need to be used to encourage exploration and discovering information (Yavas, 2022). Chaos theory is not an unusual theory in education. Education includes different situations mostly unpredictable and nonlinear. Students with

different personalities, and different levels of development are in the same environment and each of these students and lecturers learn and interpret work in different ways (Davis, Smith and Leflore, 2008). With this specific case study students and lecturers indicate that they feel that this method of instruction needs to be explored on a more regular basis to allow students to learn how to explore this kind of situations, build on their level of resilience and adaptability.

Tise (2021) emphasis the fact that uncertainty in classrooms need to be reduced and the classroom environment need to be ideal for exploration and discovering. When lecturers use this method of instruction on a more regular basis, students become comfortable with the instability, unpredictability and uncertainty and become more resilient to explore and discuss different viewpoints with their peers (Su, 2021). From this research and the results, it is evident that students develop the ability to explore situations and information together with their peers in the classroom. Different personalities react differently to these unpredictable situations but in all the groups students comment on the fact that they become more resilient and would like to discover more possibilities with the chaos theory as a method of instruction. Some students had a negative experience of this method and most of them explain that this was very unusual and different from the previous method. However, from the feedback students express the fact that communication and exposure to situations where different methods of instruction are used contribute to their personal development. As mentioned earlier, chaos theory does not represent disorder or chaos in the sense of unplanned and unorganised, however it represents unpredictability and involved complex interactions (Lartey, 2020).

This chaos method of instruction contributes not only to a deeper understanding of the work but also to a more explorative and open-minded viewpoint of students as well as lecturers. A crucial component of teacher training, particularly within Higher Education Institutions, should be the provision of comprehensive instruction on the chaos method of instruction. This training should equip educators with the skills to effectively guide students in the discovery and exploration of complex, non-linear concepts. Such preparation is essential to equip students for the unpredictable and dynamic nature of the modern workplace. This is not only applicable on education but in all fields of studies. The world and situations in the world of work is constantly changing and we need to prepare graduates to be willing to explore situations and discover the best solutions.

The only constant in life is change - Heraclitus

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