It’s Never Too Early
Education for Sustainable Development
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Abstract: This paper is based on research conducted at primary and tertiary levels in Queensland, Australia. The research was focused on examining learning about sustainable development that occurs at those levels through a particular activity: designing and making a board game related to sustainable development (SD). This research project was designed on the basis of conceptualisations of education for sustainable development that established that cognitive, moral and practical bases for learning activities should be considered during the planning process as well as the different aspects of SD (economic, cultural, social and ecological). The findings of this research demonstrated that learning about SD occurred on both levels (although the depth is different); students represented their understanding through the design activities. The artifacts created as a result of students’ learning were very impressive and illustrated the high level of understanding that occur as the result of the activity. Contextualised learning about SD (through the designing and making activity in this research) proved to be an effective way of learning about SD.

Keywords: Contextualise Learning, Education for Sustainable Development Design and Technology, Primary and Tertiary Levels, Social Sustainability

Introduction

The importance of education for sustainable development (ESD) in achieving the goals of sustainable development has been widely discussed in the literature (UNESCO, 1997, 2001, 2001a). The literature has examined ways of conceptualising ESD and approaches that could be used by teachers in different subject areas. ESD via technology education in schools is an emerging area of research (Elshof, 2003; Martin, 2003). However, while a number of resources have been developed (see, for example www.sda-uk.org and www.stepin.org), the ways teachers use them and the extent these resources facilitate students’ learning has not been fully explored. This paper presents the results of research that focused on examining the learning that occurs when sustainable development is explored by students at both primary and tertiary levels. The investigation took place through a particular activity of designing and making a board game that could inform players about sustainable development (SD) issues.

Conceptual Framework

For this research the approach developed by Pavlova (2004) for the analysis of education for sustainable development via technology education, was used to establish a framework for the research design, data collection and interpretation of results. The idea is based on the integration of two types of theories: one related to the nature of society (Habermas, 1981, Bauman, 1995, Lash, 2001); the other - to the concepts of eco-design established through associations of professional designers (Charter & Chick, 1997).

Thus, in one dimension cognitive (knowledge and understanding, eg. principles of design for sustainability), practical (designing and making products and providing services) and aesthetical (current style, appearance of products that would lead to more economic benefits as well as a sense of pleasure and satisfaction) aspects constitutes the concept of sustainability. In the other dimension, categories from ‘the quadruple bottom-line’ concept are included (the quadruple bottom line idea argues that the traditional single bottom line of profit needs to be joined by three other considerations, namely: environmental, social and ethical aspects of design). For professional designers the key aspect of ‘sustainable product design’ is the “addition and balancing of social and ethical issues, alongside environmental and economic issues, into the product design process – to achieve ‘the quadruple bottom-line’” (Charter & Chick, 1997, p.5). Although these categorisations are very schematic they still provide a useful framework for technology education teachers, as they suggest a number of dimensions that should be addressed through learning and that can be the focus for a particular activity.

Another type of theory used for designing this research project and for interpreting the results is the sociocultural theory that conceptualises learning
within a particular setting that is impacted on by historical, cultural and institutional factors (Wertsch, 1991). Thus the proposed activity of designing and making a board game was conceptualised as a purposeful human activity undertaken to meet a need as influenced by the sociocultural and physical location in which it is undertaken. Involvement in this activity was viewed as having focused on all dimensions identified above and providing an opportunity for students to understand the relationships between technology and SD in a reflective way.

**Methodology**

The methodology for this study is two case studies related to each other by the same activity (to design a board game through which the concepts of SD could be addressed) and by the involvement of the same research team. Two groups of students with around 35 people in each group were chosen: one Year 3 class from a primary school and one Year 3 group of pre-service teachers enrolled in a Bachelor of Technology Education degree. These groups were chosen as representing two very different levels of student involvement in, and knowledge of, ESD through the formal educational system. Those groups differ in such factors as age, level of education, life experience, and educational expectations. These differences were considered to be important for this research as they could help to understand how, through the specific activity of product development, students would be able to consider different aspects of sustainability and apply them in their design, and what major differences would be apparent between the age groups. The second purpose of this study was to explore the ways in which technology education, as a part of general education, could play an important role in ESD. The third purpose of this research was to examine teachers’/lecturers’ learning from their own experiences.

In both case studies the methods of action research were used to monitor students’ involvement, level of understanding, processes of learning, as well as to analyse opportunities provided by technology education in terms of learning for ESD. At the beginning of the research the project was planned in broad terms. This plan was flexible and was modified on the basis of real daily needs. The study was planned in accordance with the four stages of action research identified by Kemmis and McTaggart (1988). The research group that consisted of one primary school teacher, two university lecturers and one undergraduate Honours pre-service teacher completed the following steps in undertaking this study: developed a plan, acted to implement it, observed the results and reflected on these results as the basis for further planning.

Action research as “a form of collective self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out” (Kemmis & McTaggart, 1988, p.5) became one of the important part of the program.

At the tertiary level, the lecturer was concerned with his own practice. His concern was on how to develop students’ understanding and attitudes towards SD by the means of Technology Education through active learning. Through discussions with the members of the research team he explored ideas and possibilities for curriculum improvement. At the primary school level, the teacher was also very interested in new experiences for her students and she wanted to learn more about ESD and active learning in technology education. Thus, the research group was interested in developing approaches to ESD with the aim to improve curriculum and policy development process in the area of Technology Education.

For this study an ‘emancipatory’ action research (Kemmis, 1988) process was chosen as the approach for conducting the research. This means that the whole group takes joint responsibility for action and reflection. Although the ‘outsiders’ were involved in the action research at the school level, providing material, organizational, emotional, and intellectual support, they were participants of the action research at the tertiary level and the whole group shared responsibility equally between all members.

To succeed in changing teaching practices and students’ learning, the researcher participants had to develop new competencies. The possibility to master new practice was vital for the team’s motivation and for the success of the learning process. The renewal process is often a process of trial and error, and very seldom is it systematically planned and managed. Thus, the critical self-reflections of the team members involved in the dialectic of action and understanding was among the crucial issues. Analysis of the artefacts produced by the students, portfolios of students’ work as well as daily observations, survey and interview evaluations were used as methods for data collection. Action research was chosen for this study as it is “a concrete and practical process which helps those involved to build a critique of schooling, from the perspective of education, and to improve education in schools” (Kemmis & McTaggart, 1988, p.27) and at the tertiary level.

**Case Study 1 – Primary School**

Students involved in the project were at the end of the semester unit titled Healthy food. Their prior knowledge was related to the concept of healthy food
which they explored with their teacher. Also, through collective play in the classroom prior to the project students had become quite familiar with the concept of the board game (rules, layouts, etc.). Thus, the task was to connect the topic of healthy food with the theme of the research project. Through the discussion within the research team, the topic of introducing eco-food for a friendly monster was chosen as an appropriate activity for the age and prior experiences of the students. They were asked to develop rules as well as a playing field. The duration of the project was around 15 hours over a period of 4 weeks. The teacher led the project with input from the university members of the research team.

Through this activity two new topics were introduced to the students through one hour power point presentations followed by discussions: 1) eco-food and 2) three aspects of sustainable development: economic, social and ecological, using as an example a plastic children’s slide.

The first topic was presented at the beginning of the project. Students were asked to answer some questions and design a symbol for the eco-food. This topic was very close to students’ understanding and experiences. Their prior knowledge allowed them to grasp the essential ideas quickly and represent them graphically via an eco-symbol. Two students did not design a symbol. Five students associated their symbol with healthy food (no fat, vegetables, fruits, and used symbols with multiple interpretations). Two students associated their symbol with flowers. Two included worms, one produced a scary image and one a drawing of chemicals. Five students used eco-food words and images (such as apple, flower) and two used only words. Thus, out of 21 submitted works, 13 presented appropriate symbols with a clear message. Analysis of the eco-symbols provided an opportunity to identify three groups of symbols: only pictures, only letters and the combination of letters and pictures. Through class discussion, positive and negative features of the most typical examples such as the aesthetics, clearness of the message, practicality and simplicity, were analysed. After discussion students started their work on producing a group symbol.

The teacher facilitated the process very effectively, talking to each group, reminding the class that to have a good discussion, students need to listen to each other and help each other. Group work, group discussion and the level of involvement of students in the task, were observed by the team and highlighted by the teacher as an important aspect of students’ learning. She stated: “They had to learn to cooperate and work in groups. They also had to know each other quite well and be accepting of each other’s personalities, characteristics and strengths. And realising the children that might not be so good at writing may have good ideas to express, may be artistic, may take over different roles when they work in the groups” (the teachers’ interview). Final evaluations completed at the end of the project through a questionnaire suggested that students valued this experience. When they answered the question “what have they learnt thought the project” the majority of students responded: ‘trust each other’, ‘work together’, ‘work in team’, ‘use everyone’s ideas [while] working together’, ‘when you work together, it’s done easier and quicker’.

The second topic was on sustainable plastics. This was regarded as a ‘foreign’ topic by students. After analysis and reflections the research team concluded that the students would require much more time to understand the social and economic aspects of sustainable development in full. However, an introduction of SD concepts via a plastic slide was appropriate for the age of students and could work very well. Students started to work on their games after the introduction of the first topic, which became the main theme for their games. When the second topic was introduced, the majority of students had already chosen their game, thus the new information that they had discussed through the second topic was not included in their board game. It was interesting to observe the ways each group started to work on their designs. One group wrote down their ideas, another group drew the start and finish on their paper and started writing rules, another group designed a path, another one discussed ideas. Although they used different strategies to start, after a number of lessons they all had a draft of their game, including the rules.

When the designs of the board games were finished the playing template was drawn on paper, they were then transferred onto the fibreglass boards by the university members of the research team. In the class demonstration by the university team showed the students how to produce the game in fibreglass. This was undertaken to enrich the context of the school learning by showing a completely new process to students.

The results of this project were appreciated by the school students. They played their games for one hour and a half. The teacher stated: “they’re very proud of what they did and they still talk about the games and play the games” several weeks after the activity was finished.

In their evaluations, students stated that they learnt the following from the Honours student who introduced topic one on eco-food: the majority of students (thirteen out of sixteen returned questionnaires) related their responses to recycling. Ten students – to eco-food concepts while other responses include: how to plant a pineapple, to cooperate with each other more, not waste, make compost. In the final interview the teacher also stated:
What surprised me was the transference of the eco-system knowledge that they learned from Bob [pseudonym] into their game. I think that was surprising. They also, it was like with their games, even though it was Healthy Food and it worked in with our Unit, I think that that wasn’t what influenced it in making the game. Because what came up in the game was pretty much general knowledge about fruits, meat, chicken. Umm, what influenced them was what they learned from Bob.

From the other presenter who showed the students how to make a board game from fibre glass, students learnt: how to produce a board game from plastic (five responses); that the glass is made from sand (six responses); about recycling (three); how to make the board game better; about plastics (how to make plastics, how to heat plastics) and; about acetone. The teacher highlighted:

I think they were fascinated by how it was made. But I don’t know that they needed to know that bit. You’ve got two sides. [On the one hand] they were learning something totally foreign that they would learn at school. [On the other hand]… they liked it. So you tapped into the children from that way, that type of thinking, that type of learning – their curiosity. So there is a bonus.

In responding to the question of how they would improve their final product (the board game) the following proposals were made by the students: use brighter colours (five responses); use darker pencil (nine); change the end of the game (three); make it longer (two); give a name to the game (two); change the tracks, putting numbers; and not rush so much.

This case study demonstrated that it is possible to address issues of sustainability with very young children. Or, to draw on the title of the paper, it is never too early to start addressing issues of sustainable development. Through active involvement in thinking and making, students understood some issues, in particular, the environmental aspects of sustainable development. Although, the original plan was to focus on all dimensions of the framework, adjusting of the project on the basis of the teacher’s reflections, led to the particular focus on the environmental issues through the cognitive, practical and aesthetics aspects. This activity provided a good foundation for future activities that should address economic and social aspects of sustainable development. Such activities would aim to assist learners to adopt new behaviours in the protection and restoration of the Earth’s ecosystems and develop the capacity to identify the root causes of threats to sustainable development, and the values, motivations and skills to address them. Through this activity the teacher was surprised by the students’ commitment in developing the board game and with their perseverance in continuing their work. This project also demonstrated that technology education can be integrated with the other studies and can be used for effective learning about sustainable development. The outcomes of students’ work, their satisfaction and feelings of pride and their survey responses demonstrated that students were involved in effective learning experiences.

Case Study 2 - Tertiary Level

For the second case study the ‘Product Design - Plastics’ (PDP) course was chosen with a duration of 4 hours per week over 13 weeks. In case study 1, students were asked to design and make a Board Game for themselves. Tertiary students were asked to design it for children and they were required to choose the age of the children who would play their game. Also, more requirements were added to the project: a minimum of two children should be able to play the game together, a list of rules and a method of storing the various pieces of the game were to be produced. Students were asked, where possible, to design and manufacture all of the game components including a container in which to package their game. This was achieved through various techniques including: fibre reinforced plastics, plastic injection moulding, resin casting, artificial stone casting, epoxy moulding and silicon moulding. In addition to making the pieces associated with the games, students were also asked to design and make the board layout. To achieve this task a new process of printing onto cotton fabric was developed specifically for this project. Students were then able to design their board game either by hand or on a computer and then print their design onto the fabric using a conventional inkjet printer. The fabric was then laid in a fibre-polyester resin. This lay-up became an important stage in the making of their game. Thus, the emphasis was on the development of designing and making skills as well as learning about eco-technologies and the broad concepts of sustainable development.

Through the project students were asked to investigate, design and make a new innovative travel board game that could be made by a local community and sold to raise funds for the neighbourhood. As part of the investigation and design process, students were asked to consider topics including: sustainability, values, materials, packaging, manufacturing techniques, safety, aesthetics and appropriateness.

The lecturer’s concerns about the traditional content of the course (students typically looked only at the processes involved in the manufacture of artefacts
made of plastics including the development of several non-contextualised skill exercises and activities) provided the basis for his active involvement in the action research team.

Prior to the project students had little or no knowledge in relation to SD issues and no previous experience in working with the particular non-toxic plastics and production processes involved. Through lectures a wide range of topics including, plastics for a sustainable future, recycling, product analysis, properties and uses of plastic and board game design were covered as well as manufacturing techniques, design and safety issues.

Through the process of teaching, the lecturer observed students’ reactions to the issues discussed and the approaches they used for their design. This provided the basis for reflections and team discussions. Soon after the end of the project two high achieving students were asked to participate in an interview and answer several questions in the survey to clarify their perspectives on SD, their approaches to the task, reflections of their learning experiences, satisfaction with the task and on how a board game as a project may be used to develop an awareness about SD issues. The students were selected due to the differences in their approaches to the task observed by the lecturer. To maintain participant anonymity the students’ will be referred to as John and Sam.

The answers to the questionnaire varied considerably between participants. In the case of the first question ‘What does the term ‘Sustainable Development’ (SD) mean to you?’ John defined SD as ‘…improvements are made that are kept for longer than they have been kept in the past.’ In contrast Sam defined the meaning of SD as ‘…sustainable development means living a life which does not impact heavily on the environment and/or the world …’. It was noted that the two students had very different interpretations of SD. John took a more literal approach to SD and interpreted SD as increasing the durability of a product. In contrast Sam had a broader view on SD and was more concerned with the viability of human development and in ensuring that future generations could enjoy a quality of life equal to or better than our own. By chance, each of the two students represented one of two approaches to sustainable development: values change and technological fix, summarised by Robinson (2004).

“…One side focuses more on questions related to values and fundamental changes in individual attitudes towards nature … while the other side takes what they believe to be a more pragmatic and collective approach, oriented towards efficiency gains and improvements in technology” (Robinson, 2004, p.371). So it is possible to assume that a whole range of attitudes and beliefs were present in the classroom.

Similarly, when the respondents were asked ‘What did you learn about SD through the board game activity’ there was again a vast difference in approaches. John was not clear and his response was limited by the example he provided about the energy sources: although he had used wind and water energy in the past, he was now aware of alternatives energy sources such as ‘wave energy’ production.

In contrast, Sam had to overcome a personal moral dilemma. Sam had initially considered not participating in the board game activity because of his belief that fibreglass is a non-recyclable product and therefore unsustainable. Sam also expressed concerns that because of the unsustainable nature of fibreglass that he ‘did not want to produce a game that would also end up as landfill’.

To overcome the conflict between his beliefs and the nature of the learning assignment, Sam researched materials that would enable the final product to be remanufactured or alternatively, used as an industrial energy source. Through his research, Sam discovered that ‘Hemp and Bamboo could be used. Both are easily grown without much water, and have a natural resistance to insect attack…’ Sam investigated further the benefits of using these natural materials and satisfied himself that he would be able to complete the task, as required, and in addition, demonstrate to the other students in the class the sustainable benefits of the materials of his choice.

Through the interviews it became evident that both students had welcomed the concepts and benefits of SD, however, their interpretations of the values associated with SD were somewhat different. When asked ‘How did SD impact on the design of your board game’ John related to his experiences as a child. He had grown up on a farm in tropical North Queensland where wind and water were utilised as energy sources in the daily running operations of the farm and he confirmed this in his responses to the questionnaire, for example; ‘I chose these alternative energies as they are already in the area in which I have lived and I have some first hand knowledge of these alternative energies’.

The impact that SD made on the design of Sam’s board game was significant. Sam stated that ‘…the game has been designed to mimic its own prophesy…’ This was achieved by using “…hemp matting instead of fibre glass matting …” In addition, Sam extended the influence further by designing the figurines “…to use a minimal amount of resources and materials”.

Sam also considered the lifecycle of the product including its disposal. In the event that the board game became outdated the ‘…the hemp board and container can be recycled…’ ultimately reducing the ‘burden on landfill facilities’.
Sam not only saw the board game as an educational tool, he also attempted to address several of the issues associated with the fibre-reinforced plastics manufacturing process. Although John chose not to develop alternative manufacturing techniques, SD did play a large part in his content development for the game and the messages that this content was relaying to his targeted audience. Concerns with SD played a significant role in the design of the board games of both students.

Finally, when the participating students were asked to describe the process through which their board games were developed, John revealed that he chose to modify a board game that he believed his students would be familiar with, namely Snakes and Ladders. To meet his objective John chose the ‘water to replace the snakes and the wind turbine to replace the ladders’. These references were the same sustainable energy sources that he had grown up with on the farm.

In contrast, Sam chose to appeal to his audience on a broader level and covered a wider range of issues. To meet this objective he chose several terms associated with sustainability: wind power, solar power, permaculture, water wise and community. Sam used these terms to reinforce the principles of SD while the user was playing the game.

To incorporate these concepts into the game the Sam used them as headings for playing cards. As players move around the board they collected the cards. The cards present the notion to ‘think globally, act locally’.

A garden worm formed the outline for a map of Australia and as the players ‘move from square to square they were required to take a card. The card would instruct the player to perform a certain activity. If this activity was completed successfully the player would be awarded a figurine. The figurines, which were hand crafted by the student, represented various aspects of a sustainable lifestyle. As players move around the board game they collect the figurines and the player who collects the most of the sustainable lifestyle figurines wins the game.

The final question asked of John and Sam was - would you include SD issues in your teaching? Both participants agreed that they would definitely do so, however, Sam was more committed to the concept. He expressed the view that ‘Design and Technology Education provides an ideal opportunity for students to learn, experience and see, through real-life examples/contexts, the positive and negative impacts their creations [and choices] make and will have on societies and cultures of the future…’

The two views analysed above indicate the variety of approaches students undertook in designing and making their games. The approaches included the identification of native and introduced species of flora and fauna to Australia, alternative energy sources such as windmills and water, games that highlighted the plight of native aquatic life, treasure hunting games that focused on the natural unspoilt features of the Australian landscape and games that used movie themes such as ‘Finding Nemo’ to demonstrate how pollution impacts on our waterways.

The approaches used by the university students to meet the requirements of the SD tasks addressed several of the educational directions of UNESCO’s Chapter 36 of Agenda 21 (2004). These directives included: (1) improving basic education, (2) reorienting existing education to address sustainable development, (3) developing public understanding, awareness, and (4) promoting training. The outcomes of the activity discussed above demonstrated that by using imaginative and creative solutions to the SD tasks, the thrust of UNESCO’s approach to Education for Sustainable development could be fulfilled.

The complexity and variations to the SD tasks were much higher in case study 2 than in case study 1 where students were limited by given topics. Also the use of environmentally friendly methods of manufacturing reinforced the idea of practical approaches for sustainable development.

The lecturer’s reflection on his practice and the process of students’ learning through the Travel Board Game project demonstrated that the vast majority of students displayed a better understanding of the issues associated with sustainability as a result of involvement in the project. In addition, many of the students confirmed that they would endeavour to raise the awareness of SD with their students in high schools.

As a result of this research the following improvements to the project have been introduced to enhance students learning. Lectures will have a greater focus on Sustainable Development, including sustainable design and the use of additional sustainable plastics technology. Written assignment tasks will require students to demonstrate a deeper understanding of SD with a heavier emphasis on research that highlights how SD principles can be addressed and translated into the high school environment. Finally, a body of exemplars has been created, collated and will be used to illustrate the concepts and accessibility of Sustainable Development and sustainable design.

Two Cases Analysed
Evidence collected from the two groups of students highlighted the critical role students can play in establishing ESD learning community. The introduction of ESD via technology education can be successful and meaningful for students at different levels of
education. The conceptual framework that identifies areas to be addressed through the learning activities such as cognitive, practical, aesthetics, social, economic and environment can help to plan stimulating learning activities that provide spaces for all participant ‘voices’ to be heard, to develop a shared understanding within the learning community.

A number of similarities and differences were identified across two the groups/levels. In terms of similarities, the proposed project provided a real context for learning, helped students to understand the concepts of SD and apply these concepts in their activities. Although, in both cases, the introduction of SD into the classroom was a new concept, it was positively accepted by the students and teaching staff. In both cases social, economic and environmental aspects of SD were approached through the cognitive, moral and aesthetics dimensions, although at the primary level the focus was moved towards environmental aspects of sustainable development. The nature of the selected activity was appropriate for the age of the students because the level of difficulty could be adjusted and the number of aspects identified in the framework can vary. Due to the practical engagement and ownership of the tasks, students stayed motivated and interested and through the process of evaluations in the form of teachers’ and peers’ feedback, the activity provided students the opportunity to progress across a range of SD issues. Successful involvement of students in ESD learning is related to the active methods of teaching and learning employed in such projects.

It was also found that one project is not sufficient to develop a multifaceted understanding of SD concepts, even for university students. Students at the primary level were able to understand many aspects of SD such as social, economic and environmental, when a familiar example was given to explain them. However, all students need to have a prolonged engagement with the concepts to become familiar with them and confident in their use.

The artefacts created as a result of students’ learning were very impressive and illustrated the high level of understanding that occurred as a result of the activity. Contextualised learning about SD (through the designing and making activity) would appear to be an effective way of learning about SD. Thus, both case studies supported the assumption that technology education can play an important role in ESD. In particular, due to the cognitive, moral, practical and aesthetical engagement that helps students to stay motivated.

In terms of differences, a number were observed throughout the research project. The level of self-directed learning was higher at the university level than at the primary school level. In addition, research of the issues and discussions within the groups stimulated a student centred learning environment that was guided more by the teacher in the case of the primary students.

At the primary level students were at the beginning of the journey in terms of formulating their understanding of sustainable development. At the tertiary level two types of beliefs about the way to achieve SD were clearly identified among the university students including technical fixes and value change (Robinson, 2004). Due to these strong beliefs some unexpected learning was observed at the tertiary level: Sam’s research on environmental friendly materials resulted in the proposal and use of different material for the board game.

Another difference is related to the structure of learning. At the primary school level each aspect of sustainable development should be focused on a separate activity before students are able to consider them all combined in one project. At the tertiary level, although some students addressed only one aspect of SD, a number of them addressed the economic, social and environmental issues within one game, enabling them to interlink different aspects of sustainability.

Conclusion

Both case studies demonstrate that ESD can be successfully introduced to different ages and at different levels of education through technology studies. Students’ progression in learning at both levels was related to the nature of the activity (the task was open and it was possible to negotiate it with the teacher) and to the student-centred method of teaching.

Action research as a way of learning for teachers and academics involved in the project proved to be a useful way of addressing concerns identified for this study such as developing students understanding and attitudes towards SD by means of active learning. Action research, with an emphasis on reflection and teamwork was an effective method of introducing new competencies and practices to the teacher/lecturer. This project will be used again at both levels of education in the future, however, as a result of the research team’s reflection it will be presented in a modified form.
References


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