

Oct 19th, 9:00 AM

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Matthew Watkins
Nottingham Trent University

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Citation

Watkins, M.(2013) Fostering deep learning in respect to the social aspects of sustainable product design, in Reitan, J.B., Lloyd, P., Bohemia, E., Nielsen, L.M., Digranes, I., & Lutnæs, E. (eds.), *DRS // Cumulus: Design Learning for Tomorrow*, 14-17 May, Oslo, Norway. <https://doi.org/10.21606/learnxdesign.2013.159>

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Fostering deep learning in respect to the social aspects of sustainable product design

Matthew WATKINS*

Nottingham Trent University

Abstract: This paper presents findings from a doctoral study, which investigated effective methods for teaching social sustainability within product design courses in British and Irish universities. Specifically exploring how appropriate methods can be used to foster deep learning in respect to the social aspects of sustainable product design. The importance of deep learning is reflected in both the sustainable design education (O'Rafferty et al., 2008, Griffith and Bamford, 2007) and education for sustainability literature (Warburton, 2003). Three 'Rethinking Design' workshops were designed and developed as part of the doctoral main study to introduce students to the wider social aspects of sustainability and were conducted in five universities in Britain and Ireland. The workshops were developed to foster principles that encourage students to adopt deep learning methods, including motivational factors such as relevance, appropriate teaching materials and opportunities for collaborative learning. The workshops were successful in fostering deep learning by facilitating learning through discovery, critical reflection, peer learning and creativity leading to an exploration of design thinking solutions.

Keywords: Deep Learning, Sustainable Product Design, Net-Generation learners.

* Corresponding author: School of Architecture, Design and the Built Environment | Nottingham Trent University | UK | e-mail: first.last@uotw.edu

Introduction

This paper presents findings from a doctoral study, which explored effective methods for the teaching of the social aspects of sustainability in sustainable product design (SPD) (Watkins Forthcoming). Specifically describing how deep learning approaches were fostered through the careful design of learning materials in the 'Rethinking Design' workshops, which were conducted at 5 universities within the UK and Ireland.

The paper begins with the understanding that in order for students to fully grasp the complex, interdisciplinary and holistic nature of sustainability they need to adopt a deeper understanding of the subject (Warburton 2003).

A multidisciplinary literature review was conducted into deep learning with the key recommendations for fostering a deep learning approach relating to motivational factors including the student's perceived relevance of the teaching and the real world nature of the taught content, therefore the learning preferences of the current ('Net-Generation') learners are also considered. This paper then outlines how the findings relating to deep learning and the learning preferences of students informed the design of the 'Rethinking Design' workshops. The design and content of these workshops are then described and the findings from the study relating to deep learning including evidence of critical reflection and design thinking approaches are explored and conclusions drawn.

Deep Learning

Warburton (2003) suggests that deep learning is particularly relevant to education for sustainability, because of the interdisciplinary nature and holistic insight, but warns that the effectiveness of deep learning can be inhibited if the backgrounds of the students have a strong disciplinary focus. *"Deep learning involves paying attention to underlying meaning. It is associated with the use of analytical skills, cross-referencing, imaginative reconstruction and independent thinking (Warburton 2003)"*

The search to understand and extract meaning is recognised as a definitive trait of deep learning (Hounsell 1997; Entwistle 2000; Warburton 2003; McMahan 2006), whilst a passive memorisation and an intention to merely complete the task are described as characteristic of a surface learning approach (Hounsell 1997; Entwistle 2000; McMahan 2006; Vaughan 2006). McMahan (2006) notes, that deep learning is more effective than surface learning because it leads to mastery in understanding that is necessary in a real world application. Whilst students may have a natural tendency towards either deep or surface learning, most students' decisions regarding their learning approach depend on external factors such as their experience in the classroom (Ramsden 1997; McMahan 2006) and their expectations of how the assessment (Marton and Säljö 1997) will reward them (McMahan 2006).

Deep learning is dependent on how much a student engages with the topic (Marton and Säljö 1997; McMahan 2006) and deep approaches to learning are likely to arise from both good teaching and greater student autonomy to choose both the content and ways of learning (Marton and Säljö 1997; McMahan 2006; Vaughan 2006). Deep learning is found where students are motivated and engaged with the subject matter

(Fransson 1977; Hounsell 1997; Marton and Säljö 1997), it is recognised that such students will tend to read beyond the course requirements (McMahon 2006).

Fransson (1977) found that students who exhibited a strong interest, combined with low levels of anxiety, demonstrated a deeper approach to learning and were able to recall facts from a studied text well. Whilst students that lacked interest and felt threatened by the prospect of testing (McMahon 2006), exhibited high anxiety and were likely to adopt approaches that demonstrated only surface levels of learning (Fransson 1977). Describing approaches to assessment that could foster deep learning responses, McMahon (2006) suggests giving students greater ownership and choice (McMahon 2006; Vaughan 2006) over how and when they are assessed as well as ensuring that the assessment is designed to reward higher order critical thinking (McMahon 2006). Describing such an approach McMahon notes the use of reflective diaries and short pieces of writing that can be peer assessed, fostering the development of critical reflection through practise and feedback (McMahon 2006).

Motivational Factors

Deep learning can be associated with an internal motivation (Warburton 2003; Vaughan 2006), whilst surface learning can be associated with an external requirement (Entwistle 2000; McMahon 2006; Vaughan 2006) such as an examination. It is remarked however in the literature that this motivation isn't created by an individual but is instead found (Fransson 1977; McMahon 2006), so links between the learning material and what the students are interested in need to be made to ensure relevance. This view is supported by Ramsden (1997) who asserts that course materials or assessment methods alone are not enough to ensure that students will think deeply about the subject matter and that it is necessary to consider the students' perspective. Furthermore noting Fransson's study Marton and Säljö (1997) state a deep approach to learning is best fostered in students by considering the students' own interests, whilst seeking to eliminate factors which cause students to adopt a surface approach; irrelevance, threat and anxiety (Marton and Säljö 1997). *"A deep approach, in the context of everyday studying, primarily refers to the realisation of the fact that the studies one is engaged in deal with some aspect of the "real world" and thus by studying, one is trying to improve one's understanding of it."* (Marton and Säljö 1997)

Active (McMahon 2006) and collaborative learning (Entwistle 2000) can lead to deep learning by encouraging critical reflection (Entwistle 2000; McMahon 2006; Vaughan 2006). A peer to peer and group based learning environment is additionally recognised with the education for sustainability literature as advantageous.

It is necessary to ensure that the students are motivated in order to foster a greater likelihood of deep learning (Fransson 1977; Hounsell 1997; Marton and Säljö 1997) and Warburton (2003) notes the following considerations, which can affect motivation:

Learning Environment	Course Content	Individual Factors
Scope for discovery and problem solving	Key concepts and themes	Metacognition
Choice of study materials	Range/variety	Prior knowledge
Teaching style	Personal relevance	Experience
Social context and cooperative learning		Personality
		Morale
		Workload

Table 1: Factors that affect motivation in respect to deep learning

However the majority of the individual factors with the exception of experience and workload relate to aspects that are typically out of the scope of an educator’s control. Therefore the focus of the research study considered only how the taught course content and learning environment could be best optimised to deliver the most relevant and stimulating teaching of the social aspects of SPD.

‘Net-Generation’ Learners

In order to increase relevance the students learning styles both as designers and ‘Net-Generation’ learners was considered.

Authors use multiple terms to describe the current generation of students, including the Net-Generation. Oblinger and Oblinger (2005a) define the ‘Net Generation’ as individuals born from 1982 onwards (Howe and Strauss 2003; Oblinger and Oblinger 2005). This generation would have all typically been using computers before they were 16 to 18 years old (Oblinger and Oblinger 2005). However Oblinger and Oblinger (2005) note that the differentiating factor for the ‘Net Generation’ may be their technological experience rather than just their age. Whilst (Tapscott 1998) defines the ‘Net Generation as those born after 1977, the generation born after 1982 are also referred to in the literature as the ‘Millennials’ (Howe and Strauss 2003; Holliday and Li 2004) and ‘Digital Natives’ (Palfrey and Gasser 2008). The Net Generation would typically apply to the vast majority if not all of the students involved in undergraduate and postgraduate study in the UK during the period of the study (2010-2011) and therefore all those students subject to this research study. Allowing for mature students, as an individual born in 1982 would be 28 years old at the start of the main study trials, whilst traditional undergraduate students would be aged between 18 and 22 years.

The Net Generation have differing learning styles and preferences to the generation that preceded them (Barnes, Marateo et al. 2007) typically known as ‘Generation X’. This is partly due to the influence of computer technology, the internet and the social media upon their lives and also partly subject to the social climate (Tapscott 2009) in which they are raised and their response to the attitudes of the previous generations (Howe and Strauss 2003).

Autonomous

‘Net Generation’ learners in Higher Education prefer to be autonomous learners with a preference for experiential (Barnes, Marateo et al. 2007), learning by doing

(McNeely 2005). Such students place a greater emphasis on exploratory learning by discovery, whether individually or collaboratively with their peers, to the traditional lecture format where information is given to them (Oblinger and Oblinger 2005; Tapscott 2009). Tapscott (1998) notes that this exploratory style improves students' retention of information and allows for more creative and meaningful use of knowledge (Tapscott 1998).

Oblinger and Oblinger (2005b) note that the Net generation are very achievement oriented and have a preference for structure, seeking parameters, rules, priorities, and procedures; they are keen to know what it will take to achieve a particular goal.

Socially Orientated

Net generation students are attracted to activities that promote and reinforce social interaction including interactive learning (Barnes, Marateo et al. 2007; Tapscott 2009), peer to peer learning (Oblinger and Oblinger 2005) and teamwork activities (Howe and Strauss 2003; Oblinger and Oblinger 2005; Barnes, Marateo et al. 2007; Tapscott 2009). This social nature of the Net generation means that they typically dislike online learning environments or distance learning, (McNeely 2005) despite the technological focus because distance learning lacks the social interaction that a traditional learning environment offers. Tapscott (2009) notes benefits of this social approach describing how students start to internalise their learning when they start to discuss it amongst themselves (Tapscott 2009). Oblinger and Oblinger (2005b) note that a peer-to-peer approach, where students help each other is seen by Net generation students as more credible than a teacher led approach.

Of particular interest to sustainability, it is noted that the Net generation are keen to engage in community activities, preferring to work on things that matter, such as addressing an environmental concern or a community problem (Oblinger and Oblinger 2005). Howe and Strauss (2003) similarly note that there is more emphasis on academic programs that serve public rather than individual interests (Howe and Strauss 2003).

Visual learners

Net generation students are visual learners (Holliday and Li 2004), with enhanced visuo-spatial skills (Oblinger and Oblinger 2005; Tapscott 2009), who are more comfortable in image-rich environments than with text (Oblinger and Oblinger 2005; Windham 2005; Tapscott 2009). Net generation students retain on average 30% of what they see but only 10% of what they read and prefer to have graphics before text rather than graphics following text (Oblinger and Oblinger 2005). Oblinger and Oblinger (2005b) note that Net generation learners have a highly developed visual literacy, with the ability to read images and instinctively communicate through visual methods. They are also capable of combining images, text and sound seamlessly (Oblinger and Oblinger 2005) and this is demonstrated by the prevalence of amateur You Tube content.

Multitasking learners

Net generation learners seek and handle information differently to previous generations. They multitask (Holliday and Li 2004; Barnes, Marateo et al. 2007), quickly shifting their attention from one task to another and can work on two tasks

simultaneously (Oblinger and Oblinger 2005) and deal with information in nonlinear ways (Oblinger and Oblinger 2005). Net generation learners respond more quickly than previous generations and expect rapid responses in return (Oblinger and Oblinger 2005). However it is suggested that this rapid pace may be detrimental to the student's ability to reflect and adopt critical thinking skills, which is cited as a weakness of the Net generation (Holliday and Li 2004; Oblinger and Oblinger 2005).

Design of workshop Activities

Three 'Rethinking Design' workshops were developed to introduce students to a range of social aspects of SPD, these workshop were conducted at 5 universities 4 in the UK and an Irish university and were conducted with approximately 150 students in total. Each workshop consisted of two elements, a 3-5 minute audio visual (AV) introduction and a 45 minute group based workshop session in response to the AV introduction.

The choice of these particular elements was supported by the literature, which suggested that the audio visual and group based approach taken with the workshop should be beneficial to the students' learning in a number of ways, such as:

- Increased relevance through the visual methods used (Oblinger and Oblinger 2005; Windham 2005; Tapscott 2009) and team work (Howe and Strauss 2003; Oblinger and Oblinger 2005; Barnes, Marateo et al. 2007; Tapscott 2009).
- Encouraging students to personalise aspects of sustainability through indirect experiences (Murray 2011) by using carefully selected photographs.
- Group work that builds opportunities for discussion, debate and critical reflection as well as engagement (McNerney and Davis 1996; Huckle and Sterling 1997).

The A/V presentations were designed to be contemporary in style using photographs and music to capture the students' attention, deliberately mimicking internet based media content such as You Tube, where images or silent video are overlaid by a piece of popular music. This style was adopted so that the A/V material was more readily relevant to the 'Net Generation' audience, who are able to weave text, images and sound in a natural way (Oblinger and Oblinger, 2005). Ensuring that the A/V introductions were relevant and contemporary in nature was an important consideration, as the introductions sought to foster deep learning by motivating students, as recognised in the literature through the use of culturally relevant learning materials that related to real world issues (Fransson 1977; Ramsden 1997) (Marton and Säljö 1997). The photographs used were intentionally selected to portray a number of different aspects echoing the well-known Chinese proverb, "one picture is worth ten thousand words", so that each A/V introduction could introduce a much larger range of social issues than a traditional lecture format could accommodate, if only at superficial level. The use of photographs was also chosen as the literature findings suggest that the use of images can elicit an indirect experience that can foster personalisation of sustainability (Murray 2011). Furthermore, Griffith (2007) cites the use of introductory audio visual presentations as a means of promoting interest in responsible design amongst students, as well as supporting lecture content and stimulating discussion and activities in tutorials.

The group based aspect of the workshops was developed to further adopt approaches that intended to meet the learning preferences of the students. Including:

- Contextually relevant content in each of the workshops to suit the modules being undertaken at each university.
- Opportunities for collaborative group work to enhance peer learning and critical reflection.
- The use of questioning to elicit reflection amongst learners.
- Fostering deep learning through critical reflection.
- Enabling learning by discovery a learning preference of students.
- Fostering a holistic approach to enable systems thinking.

Methodology

The 'Rethinking Design' workshops were conducted at 4 universities in the UK and an Irish University amongst undergraduate and postgraduate product design students. The total sample size was approximately 150 students and the workshops were conducted within modules which considered sustainable design. Data was collected via a mixture of methods including two student questionnaires which were completed prior to students commencing the workshops and immediately after completion to measure differences in individual students understanding and attitudes. Audio recordings and photography was used to record the students interactions during the workshops and the audio recordings were transcribed and analysed alongside the images using coding and clustering techniques. Student reflective diaries were additionally evaluated from the in-depth case study institution and were also analysed using coding and clustering techniques. Coding and clustering was used to analyse the qualitative data because this approach enables data to be reviewed and dissected in a meaningful way whilst still keeping the relationships between the data intact (Miles and Huberman 1994).

Workshop Findings

The literature review demonstrated a link between deep learning, collaboration and critical reflection (McMahon, 2006) therefore the findings considered how these attitudes featured in the analysis of the student workshop experience, alongside the consideration of a design thinking approach amongst the students.

The group based discussion and workshop exercise demonstrated detailed consideration of the material with students exploring the A/V introductions at a deeper level, with a number of observations consistent with deep learning. Students engaged with the content of the A/V introductions at a personal level as well as engaging collaboratively in critical reflection, discussing issues such as the designer's responsibilities and the complexity of child labour in developing nations as well as suggesting approaches which foster design thinking principles.

Group work

Students demonstrated group discussion and debate within the workshops and some even reflected upon this collaborative aspect later in their diaries. Suggesting that the group work and group discussion within the workshops encouraged them to consider different opinions and viewpoints. One student in particular noted that the

group work element of the workshop was particularly beneficial to his learning by offering a peer-peer learning environment.

"I felt that the group discussion was an excellent approach to the learning outcomes. It is in my opinion that students learn more from each other if they carry out projects in groups."

Students additionally reflected on the conflicting views that arose within the group discussion, recognising that there were often two viewpoints or arguments to a particular issue, as a result of this. For example when considering the exploitative labour in developing countries through the 'exploitation' workshop, students recognised that whilst inequality of low wages, long working hours and child labour was wrong, it still provided the workers with much needed employment. Similarly, when considering the detrimental environmental and social impacts of globalisation and the more sustainable opportunities offered by localisation, the students recognised that a localisation approach would still have a negative effect for workers in countries such as China, that rely on the current global market model. Such examples demonstrate how the students grasped the complexity of sustainability through critical reflection.

The students' learning however, continued beyond the group based workshop exercises, with students demonstrating even greater amounts of reflection and critical reflection, and a grasp of design thinking in their individual reflective diaries. Additionally students also recognised the reflective benefits of the data collection methods.

Questionnaire Reflection

In their reflective diaries students noted that the questionnaires that were conducted at the start and end of the workshops had elicited reflection, initially upon the questions identifying aspects that they didn't understand and also on the purpose of the questionnaires. *"The purpose of the survey was to determine how much every student understood about design. In my opinion, this was a good start to the workshop. It helped me to determine what I needed to know after finishing the workshop."*

These students later reflected on how their thoughts, perceptions and knowledge had changed through the course of the workshops, comparing their responses in the final questionnaire with those in the initial questionnaire.

"After the workshop we were then asked to fill in the same survey as we did before the workshop. This was interesting because my thoughts and knowledge of the aspects had changed or broadened. The videos and subsequent discussions had broadened my thoughts on the power of designing, that as well as functionality, aesthetics and a message, a design can have social benefits and bring people closer together to help make people's lives better."

The students also typically found that the questionnaires were beneficial to them because of the ability to reflect upon what they had learnt, which was an unexpected outcome as the questionnaire was initially intended solely as a data collection and measurement tool. *"After watching the video and discussing the topics, we all had to complete a second survey individually..... I believe that this was an excellent way to end the workshop. It showed how much we learned from the presentation and the difference from what we knew at the start."*

Reflection

The time taken between students completing the workshop sessions and writing up their diaries enabled them to reflect further and combine their thoughts on all three workshops into a personal account of their experiences and reflections upon the activity. The student's reflective diaries noted how the workshops, caused them to reflect upon the decisions that they make as consumers as well as designers, with students reflecting upon what they saw, personalising aspects of sustainability by contextualising what they saw in terms of their own lifestyle or experience. An example of this was students recognising how they would feel an affinity to something they have made relating to example given for localisation.

Students reflected upon and unravelled issues that underlined some of the topics explored within the workshops, beginning to question macro themes such as globalisation and mass production. *"So maybe it is fair to ask if there is a need to mass produce items on such a large scale with such negative outcomes."* (A student's concluding diary remark)

Students also reflected on more specific micro issues such as the effect of technology growth upon communities such as the elderly. *"Technology is getting more and more sophisticated with every day that goes by but as we improve technology are we complicating things for different people in society."*

From a particular image used in an A/V introduction of a teenager in front of a boarded up house, students reflected upon social issues relating to a lack of community, family and broken homes. Such responses were framed entirely from the student's collaborative reflection and consideration of the short A/V introduction given in each workshop without any external input from lecturing staff, by allowing students the space and tools to explore concepts fully.

Furthermore the workshops encouraged students to consider the role of design and question the place of design in respect to numerous social aspects of sustainability, considering and discussing numerous issues such as design for need, noting how design for all isn't always possible and identifying cultural differences relating to age, ability or ethnic origin. Within this students also differentiated between the need to design for 'true needs' or 'needs and not wants'. In particular students reflected upon the conflict between the developed and developing world and how workers producing luxury goods for developed markets can often not afford their own basic needs.

In their diaries students also reflected upon how their own preconceptions of what design was, had changed. *"I thought about how a simple design or idea can have a big impact. Not on a consumer of an item, but on a community or a way of life. It made me really think about the power of design, as well as the responsibilities of designers to stay relevant and that as well as being fashionable or popular, that design has an important message, or in this case an important cause."*

The students also considered whether design was responsible for the issues portrayed, what the responsibilities were or should be upon designers and whether designers can be expected to be responsible for the effects of their products past the design stage, particularly in manufacture and at the end of life. *"It showed me that as a designer I have an obligation to use the talent and career that I have been given to help others"*.

Expanding on these issues of responsibility students highlighted the need for and potential approaches to address consumers' awareness of societal attitudes and values that are wasteful and harmful to the environment and society as a whole. Considering the prevalence of waste students noted social implications such as increasing consumer

awareness with students relating it to examples they are aware of such as the Remarkable pencil cases and suggested the consumer considers the need of a product at purchase in relation to wellbeing. *"You should think about it when you're buying it. You should think to yourself oh what effect is this product going to have on my life."*

Students also recognised the importance of the social implications of localisation concerning job creation and reflecting on the importance of maintaining cultural identity. *"But they were like making chairs to like give them money, yeah like the people. That makes sense and cos they can sell it can't they. Makes shipping pointless. So it provides opportunities. If they all started working for us they might lose their sense of cultural identity."*

Design Thinking

Evidence from both the student's reflective diaries and workshop recordings demonstrated design thinking had taken place, with students using their creativity and knowledge to resolve issues outside of the remit of the traditional designer. Students questioned how they could address the issue of exploitation arising from globalised production, suggesting solutions that raised consumer awareness including labelling on products that would enable consumers to trace the product in a similar way that meat in Ireland can be traced. *"We first looked at the Irish beef market where you can trace meat from farm to fork and thought the same process could be employed in the manufacturing industry each material and component could be traced back to a country and company of origin making every link visible in the chain."*

Students also discussed corporate transparency, which would require manufacturing outsourcing in the developing world to become a public procedure promoting transparency and good practise. *"Doing business in this public theatre would hopefully guide companies to a higher moral ground in fear of being shunned by consumers."*

Both examples were suggestive of a service based approach to problem solving, which is an important recognition in the shift to a sustainable mind-set, from products to service based solutions (Morelli 2003). In addition to students adopting design thinking skills, students also began to consider and discuss the need for a redesign at a systems level approach to address the issues covered in the workshops. Demonstrating a grasp of the complexity of sustainability and the requirement for a systems approach to thinking as noted in the education for sustainability literature (McNerney and Davis 1996; Huckle and Sterling 1997; Wals and Jickling 2002; Cortese 2003; Warburton 2003; Li and Williams 2006; Henry-Stone 2010).

Conclusions

Students demonstrated design thinking in both the workshops and diaries, using their creativity and knowledge to resolve issues outside of the remit of the traditional designer. Therefore despite Warburton's (2001) assertions that a strong discipline-specific focus can harm the potential for deep learning, students from a single discipline background managed to recognise the interdisciplinary nature of sustainability and consider solutions outside of their discipline focus. The success of the 'Rethinking Design Series' workshops in fostering design thinking agrees with literature, which notes that brainstorming and reflection are key components to enabling design thinking (Seidel and Fixson Forthcoming).

The 'Rethinking Design' workshops went beyond the traditional transmissive learning model, where students evidence surface learning, to a transformational learning experience with evidence of students demonstrating deep learning. The workshops were successful in enabling students to relate to the workshop content personally fostering deep learning through personalisation and critical thinking, which led students to adopting new approaches in relation to the material.

The audio visual method used within the workshops was described as relevant, effective and even enjoyable by the students, suggesting that the approaches adopted led to a relevant teaching style meeting a key requirement of deep learning as noted in the literature. Furthermore the A/V introductions in conjunction with the accompanying workshop questions encouraged student reflection, whilst the group based elements encouraged students to examine their own interpretations and those of their peers critically by fostering discussion and debate in response to each A/V introduction. This collaborative element led to a consideration of different perspectives and fostered critical thinking through the recognition of multiple perspectives.

- The workshop methods fostered a relevant approach which encouraged students to adopt deep learning responses to sustainability, despite the strong discipline specific environment, negating the concerns of Warburton (2001).
- The workshop format encouraged students to explore social SPD holistically, fostering design thinking approaches.
- The design of the workshops encouraged students to personalise sustainability and change their attitudes in respect to their outlook, both as designers and individual consumers.
- The workshops represent a container for the key elements needed to create a learning atmosphere where students can creatively explore the social aspects of SPD holistically through reflection, personalisation and collaboration. Rather than representing a one size fits all approach to the fostering of a holistic understanding of the social aspects of SPD.

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