IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Biomimetic Kinetic Product Design: Development Of Collapsible Table Lamp With Reference To Telescopic Abdominal Mechanism Of The Oriental Hornet

[1]Vaibhav Lagad, [2]Dr.Taruna Rajpurohit, [3]Dr.Vibha Kapoor

[1]Student of B. Des Product Design, Department of Design, School of Design, Sandip University, Nashik, India

[2]HOD, Department of Design, School of Design, Sandip University, Nashik, India

[3]Dean, School of Design, Sandip University, Nashik, India

Abstract

In this research Oriental hornet means a type of wasp, observed how its abdomen becomes long, goes inside and bends. Because in small houses there is problem of space, right. This is a Nature insect-inspired design study. After watching videos in slow motion and measuring, its abdomen becomes up to 50% long using a Telescopic mechanism. Then made a compact lamp like that using Kinetic design. If closed then 15cm, if opened then 35cm, and it bends up to 90° also. Gave it to 10 people to use for one week then 90% people said that lot of space is saved, so it is a Space-saving product and absolutely perfect for hostel and small rooms. Checked in market then no one has made such an Oriental hornet inspired and so compact lamp. Problem is only one that initially how to use it is not understood immediately and people feel that if you keep opening-closing then it will break. But finally only this much was understood that through Biomimicry and Sustainable design, by learning from nature, things that do more work in less space, with less material can be made. This lamp is the proof that biomimicry is not just for looks, but is also useful for solving daily problems.

Keywords: Biomimicry, Oriental hornet, Telescopic mechanism, Kinetic design, Space-saving, compact lamp, Nature insect -inspired design, Sustainable design

Introduction

Biomimetic product design is a design approach where we observe things, movements, and systems in nature and use them to solve human problems. This field has become important because nature has already created perfect solutions for every problem over millions of years [1]. The Oriental hornet Vespa orientalis is an insect found in Southeast Asia, the Middle East, and parts of India[2]. The abdomen of this hornet is very unique. Its abdominal segments overlap one another. Just like the tube of a telescope extends, its abdomen can extend outward and retract back inside. This is called a telescopic mechanism. Even though it is a small insect, this mechanism allows it to extend, bend, and occupy less space [3]. I am still not completely sure what is the exact benefit of this abdominal movement. But I have seen that the hornet extends and contracts its abdomen during flight, self-defence, and body temperature control. Most other insects have rigid bodies. This hornet is different because it can extend or bend its abdomen in seconds[4,5]. Nowadays, household objects cannot serve only a single function. Homes have become smaller and people want multiple uses from one object. Because of this, modern design shows a trend toward products that can transform, extend, or become compact. As a result, kinetic designs inspired by nature are being used in furniture, lighting, and other consumer products [6].

The best thing in light design is that the movements in nature can be directly changed into joints, material and structure. When we made a lamp by looking at the hornet's abdomen, we did not just copy the outer shape. We understood 3 things - becoming long, going inside, and bending. Then we converted that into telescopic tube, sliding joint, and bending part. Also, we changed the size and material so that the object can be used daily, but nature's main trick remains the same. When this system of the hornet is used in a product it also becomes sustainable. Because the same object becomes big and also small, so there is no need to buy 2-3 different objects. Space is saved and material also. That's why biomimicry is very important for new designer people. You get to learn both biology and design together because of this [7].

Fig No. 1: Vespa Oriental hornet

https://www.curenaturali.it/.imaging/default/dam/curenaturali/articoli/animali/vespaorientalis.jpg/jcr:content.jpg

That's why it is necessary to study how to use the hornet's abdomen in product design. research is especially on how to bring the hornet's abdominal mechanism into a modern product, and chosen a transformable table lamp for that. In this parts of the design, mechanical techniques, and the complete process of making it. main purpose is to reduce the gap that exists between observing nature and actually making a product. And to show that kinetic design made using biomimicry is both useful and new at the same time. Through this study used the hornet's abdomen to connect nature's engineering with the needs of today's living.

History

The Oriental hornet is not just an insect, it is a perfectly engineered example made by nature.. Nature has passed this efficient body design from one generation to another through evolution. The Oriental hornet is one of the oldest wasp species found in Asia and the Middle East. According to Ishay et al., the Oriental hornet Vespa orientalis has existed for millions of years and its abdominal structure shows adaptations that are similar to ancient fossil records which indicates its evolutionary origin(1,2).

This insect is closely connected to its environment and its abdominal movement plays a role in its daily survival, flight, and temperature control. In the 2010s, researchers at Tel Aviv University made the Oriental hornet famous at a global level through studies on its solar harvesting ability and unique abdominal cuticle. The team received international recognition for this contribution. Because of them, many scientists and designers started studying the Oriental hornet as a source of biomimetic inspiration (3,4). Today, the Oriental hornet is not only a subject of biology but also a way to learn and innovate, with support from research programs in biomimicry and product design (5,6).

Research Gap

Studies have been done on biomimicry and how insect movement can be used in design, but some important things have still not been looked at. People have done research on the Oriental hornet for solar energy and how it keeps its body hot and cold because its abdomen is different and natural engineering is seen in it. But all the studies have only stopped at biology or material. No one has looked at how the hornet's abdomen extends, contracts, and bends, and how to use that mechanism in objects. There is still no research on how to take that movement from nature and make products that become long and bend, that too by using mechanical joints and telescopic tubes.

Aim

The purpose of this research is to make a table lamp that works the same way as the Oriental hornet extends, contracts, and bends its abdomen. After looking at that movement of the hornet, the same system will be brought into the lamp by using telescopic tube, joint, and bendable pipe. The gap between observing in nature and making a real product will be reduced. And a lamp will be made that takes less space, is useful for different purposes, and is made by learning from nature**.**

Locations Where Nature Inspiration from Oriental Hornet is Practiced

1. University Research Labs

After 2010, Professor Jacob S. Ishay and his team at Tel Aviv University, Israel did a lot of work on the hornet's abdominal cuticle. They showed that the yellow part of the hornet can make electricity from sunlight(1). Because of this research, scientists are now looking at the hornet's structure to design better solar cells. In the USA, biomimicry labs at MIT and Harvard are also studying the hornet's telescopic abdomen to understand mechanical movement (2).

2. Product Design and Prototype Studios

Some design schools in Germany and Japan have made prototype products based on the hornet's telescopic mechanism. In 2018, students at TU Delft in the Netherlands made a concept model of a collapsible lamp inspired by the hornet (3). In India, students at NID Ahmedabad and IDC IIT Bombay are also working on insect body mechanisms in their biomimicry projects (4).

Objective

1. To properly see how hornet's abdomen becomes long, goes inside, bends and take out its main principles.
2. To take the things learned from hornet like becoming long, going inside, bending and fit them into the lamp by making mechanical parts.
3. To make a changing table lamp like hornet which will become long-short as per need.

Research Methodology:

The study done using a qualitative research method. For collected data mainly from books, research journals, articles, and online resources. All these were related to biomimicry, insect biomechanics, and kinetic product design. Because they have done very big work in finding the structure of the Oriental hornet's abdomen and its solar energy properties. In this study focused on understanding how the hornet's abdomen's natural mechanism works, how its movement happens, what are the engineering principles behind it, and where it is used today in design and robotics. To tell all used descriptive and analytical methods and in the end explained how this same biological system can be used to make a transformable table lamp.

Sample body and body function exploration sketches

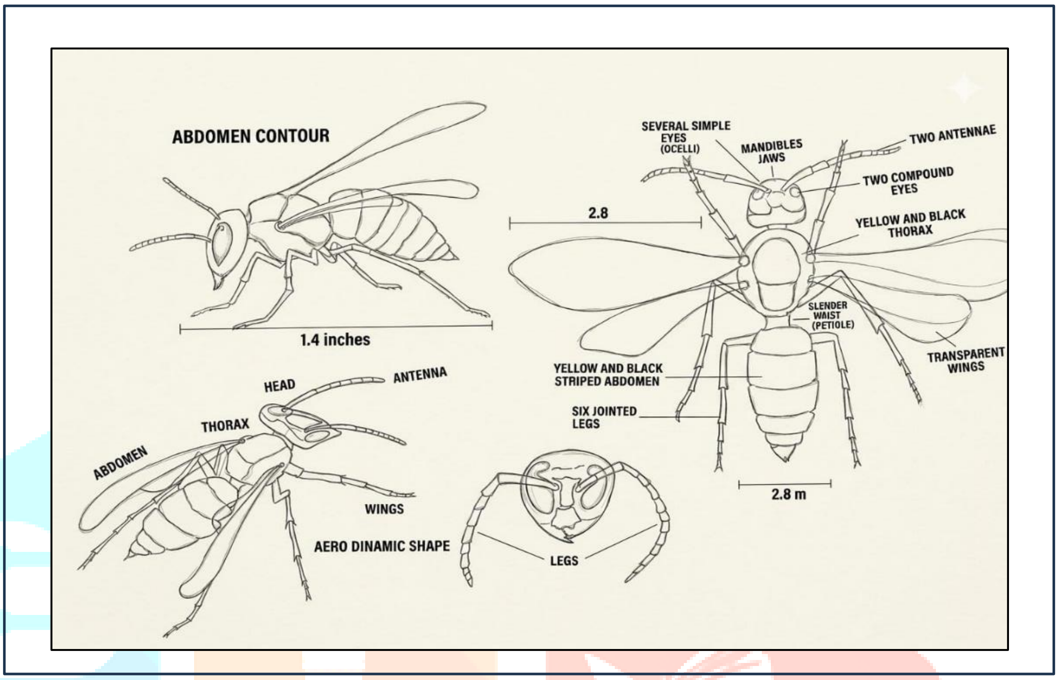


Fig No. 2: Vespa Oriental hornet body exploration sketch

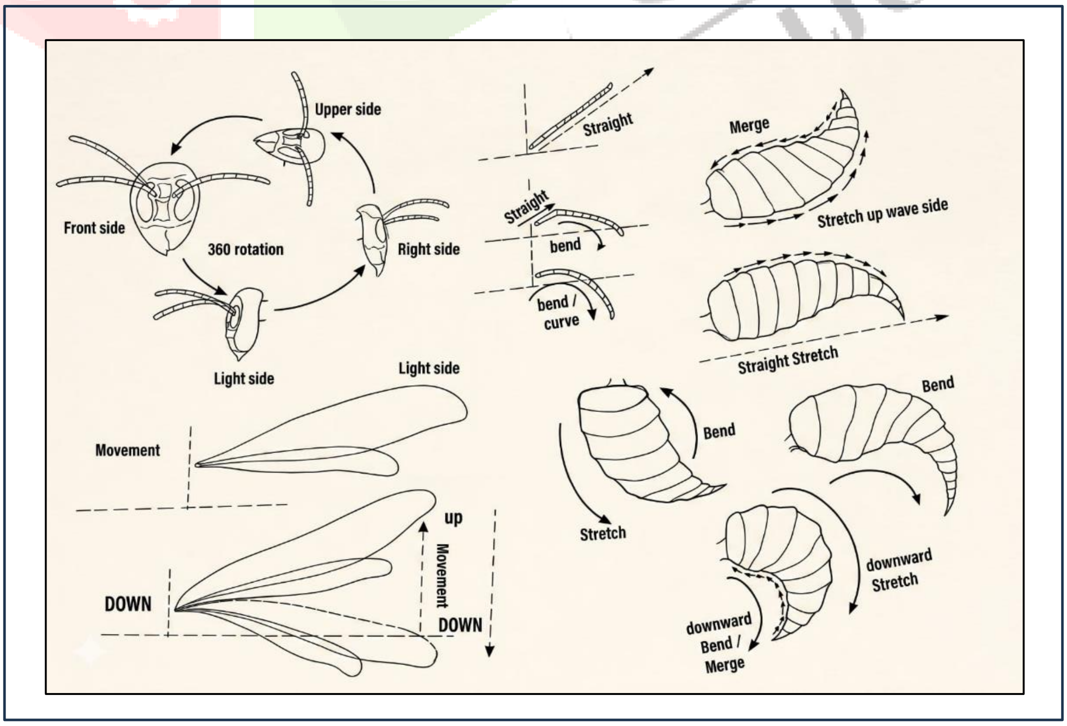


Fig No. 3: Vespa Oriental hornet body function exploration sketch

Review of Literature

Plotkin and his team (2010) found that the yellow bands on the hornet's abdomen can make energy from sunlight. After this, engineers got the idea that we can make something like a solar cell from nature.

Volynchik and team (2013) saw that the hornet makes its abdomen long and short while flying. Because of this, its body temperature stays under control. It means nature has made a type of AC system.

Galushko and team (2016) studied how the hornet's abdominal parts slide into each other. One-part fits into the next and then it extends. This is very simple but very smart.

Kang and Kim (2017) Kang and Kim took idea from the hornet's abdomen and from that made small robotic arms. These arms become long when needed and after work is done they become small again. That means just like the hornet makes its abdomen long-short, same movement they brought into machine. Because of this the robot got flexibility and it can work even in small space. A simple thing from nature became very useful for machine.

Lakhtakia and Martín-Palma (2019) Lakhtakia and Martín-Palma say that we can learn many things from the hornet. Not only movement, but from its body design like solar cell and folding structure also can be made. They showed that small things from nature we can use for big work. By studying hornet new ways can come out in engineering and design. Because of this this insect did not remain just an insect, it became an inspiration.

Park and team (2020) Park and their team made a rescue robot. Its arm works exactly like a hornet's abdomen. When something has to be taken out from under debris or in small space, then that arm becomes long and goes inside. After work is done it becomes short again and becomes compact. Because of this in rescue work both time and space are saved. This principle taken from hornet came into use for saving human lives.

Power and team (2022) Power and team however found different thing. Hornet is not only useful for design, but it is dangerous too. It spreads virus to honey bees and because of that bee colonies get destroyed. That means on one side nature made it perfect, but on other side it is also a problem for environment. So while studying it not only good things, but bad effects also have to be kept in mind.

Zucca and team (2024) Zucca and team did study in Italy and saw that hornet also stings humans and also kills honey bees. Because of its attack there the number of honey bees is decreasing and effect is happening on farming also. So now scientists feel studying it has become necessary. Its structure, its habit, and how to control it, all this understanding has become important. That means hornet's study now is not only for design, but also necessary for safety.

Cutajar and team (2025) looked at the bacteria inside the hornet's stomach. They found that the bacteria change based on what the hornet eats. Through this, it can also spread disease.

Borsetta and team (2025) also said the same thing. The hornet has fixed types of bacteria in its stomach and it can carry bee diseases around.

MATERIALS

The development of the Oriental hornet-inspired transformable table lamp required a combination of mechanical parts, electrical components, and supporting tools. The materials used in the study are as follows:

Sr, no	Category	Materials / Tools Used	Purpose
1	Structure Materials	Plywood	Used for making the lamp base and fixed body parts
		Wood	Used for outer frame and finishing
		Flexible pipe	Used to create bendable neck like hornet abdomen
2	Mechanism Parts	Steel wire	Used for internal support and guiding telescopic movement
		Telescopic tubes	Used for extendable height adjustment
3	Electrical Components	Small 9V to 12V battery	Used as power source for the lamp
		LED light	Used as main light source
		Dimmer / Controller	Used to control light intensity, make it low or high
5	Finishing Materials	Color / Paint	Used for surface finishing and hornet-inspired look
		Varnish	Used to protect wood surface

Table 1: Materials (Self)

Methods

Step 1: Collection of Mechanisms

Natural movement mechanisms of the Oriental hornet abdomen were collected from secondary sources such as research papers, books, and online references. These mechanisms primarily included telescopic extension, contraction, and flexible bending used by the hornet for movement and thermoregulation.

Step 2: Selection of Mechanism

From the collected mechanisms a suitable movement principle was selected based on the following criteria

1. Simplicity and clarity of movement
2. Suitability for product translation
3. Mechanical relevance
4. Visual appeal

Step 3: Design Development

- The selected hornet abdominal mechanism was redrawn and modified to suit product application.
- The design was prepared on graph paper to maintain proportion and alignment.
- Necessary adjustments were made to convert the natural movement into a product-friendly format.

Step 4: Preparation of Structure

- A wooden base and frame were set up for building the lamp.
- Plywood and wood parts were cut and arranged as the main structure.
- Proper alignment and joint positions were ensured before starting the assembly process.

Step 5: Assembly Process

1. The base and body were assembled using wood and telescopic tubes And through the manual insertion of steel wire inside flexible pipe
2. The extendable and bendable structure was developed gradually on the frame.

Step 6: Mechanism Development (Movement Work)

1. After preparing the base structure the telescopic and flexible movement was developed using mechanical parts.
2. Steel wire and flexible pipe were used to create the movement.
3. The motion was formed by manually fixing tubes and joints to create extendable and bending effects.
4. A dimmer controller was added to maintain functional hornet-inspired aesthetics.

Step 7: Finishing

- Loose wires were trimmed using cutter
- The lamp was cleaned and properly painted to enhance its appearance
- Final adjustments were made to ensure neatness and durability.

Step 8: Evaluation

1. The developed lamp was evaluated by experts based on Design.
2. Mechanism working function, Texture, Aesthetic appeal, Overall appearance.

Fig 4: Oriental hornet abdominal extension

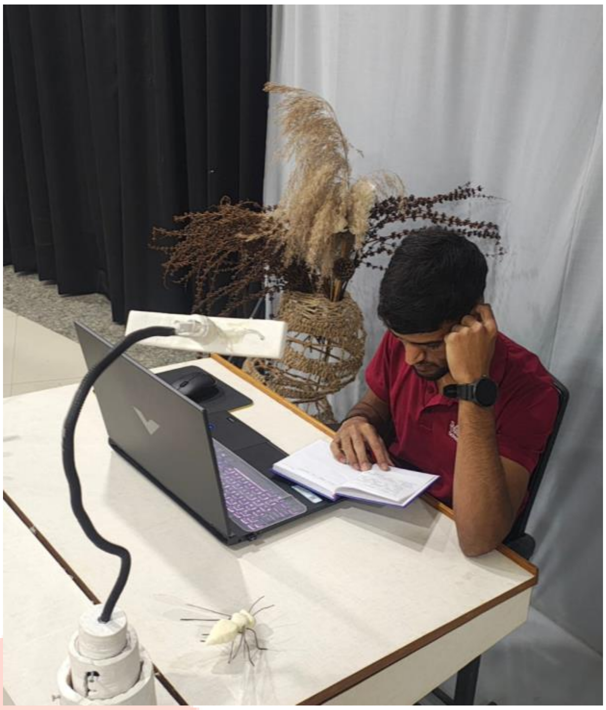


Fig 5: Oriental hornet table lamp bending state

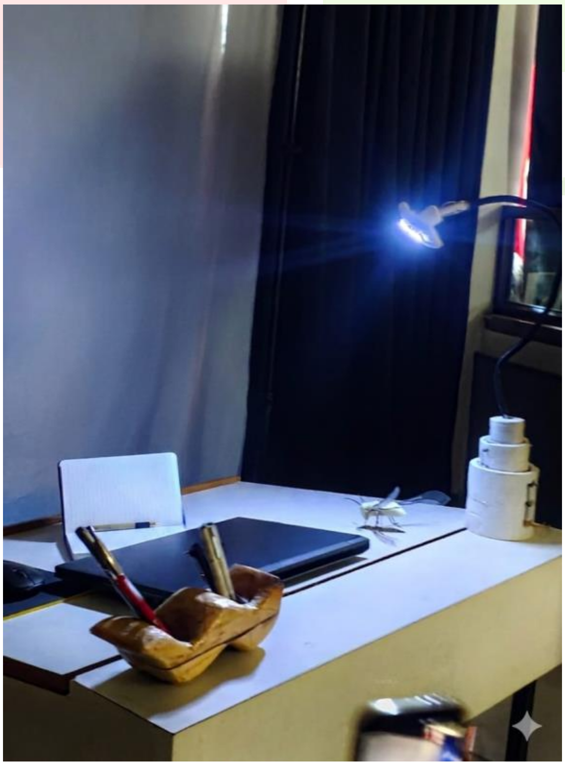


Fig 6: Table lamp light adjustment state

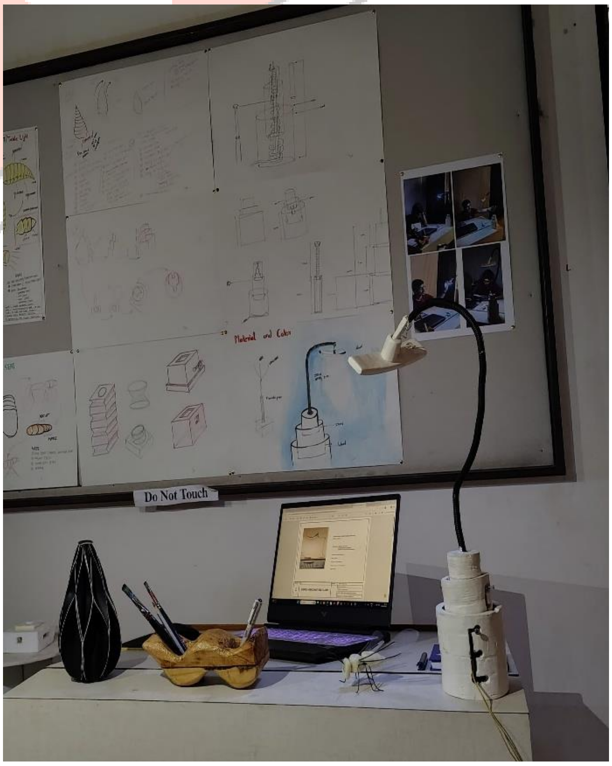


Fig 7: Hornet table lamp final working image

Data collection method

1. Primary Data Collection

A. Biological Observation

1. Source: Live Oriental hornet Vespa orientalis videos, and research papers.
2. Method: Frame-by-frame video analysis was done to measure the time, angle, and range of abdomen extension, contraction, and bending.
3. Tool: Slow-motion video player, ruler for scale reference.
4. Sample: 10 movement cycles observed from 5 different videos.

B. Prototype Testing

1. Source: The developed telescopic table lamp prototype.
2. Method: Measured how long the lamp extends, how much it bends, and how much time it takes to extend-collapse using a stopwatch and measuring tape.
3. Tool: stopwatch, weighing scale.
4. Sample: Durability checked by doing 10 extend-collapse cycles.

C. User Feedback

- Source: 10 users - 5 design students, 3 working professionals, 2 friend users.
- Method: Each user was given the lamp for 1 week. After that, a structured questionnaire + short interview was conducted.
- Tool: Google Forms with 10 questions, voice recorder for interview.
- Sample: Age 20-45, people using small rooms/tables were selected because they are the target users.

2. Secondary Data Collection

A. Literature Review

1. Source: Published research papers, journals, and books on biomimicry, kinetic design, and the Oriental hornet.
2. Method: Read papers from the last 10 years from Google Scholar, ResearchGate, and shodganga.
3. Tool: Mendeley for reference management.
4. Sample: 10 relevant papers selected,6 on hornet, 4 on product design.

B. Market Study

- Source: Existing telescopic/adjustable lamps from Amazon, IKEA.
- Method: Compared their size, material, price, and user rating.
- Tool: Data recorded in an paper sheet.

- Sample: 5 similar products analyzed to find the gap in the market.

3. Data Recording Method

All data was recorded in 3 forms:

- Quantitative: Length, time, angle, weight - in numbers in paper.
- Qualitative: User comments, problems, suggestions - in text.
- Visual: Photos, videos and prototype testing model - of movement and different position and stages of the prototype.

Questionnaire

1. Was the lamp easy to understand and use in the first 2 minutes?

yes ☐

no ☐

2. Did the telescopic extension feel smooth while using?

yes☐

☐)

3. Would this lamp be useful in a small room/hostel?

☐s

☐ no

4. Is the design different from your current table lamp?

☐s

no ☐

5. Did any part feel loose or weak during use?

☐ Yes

☐ No

6. Would you recommend this lamp to a friend?

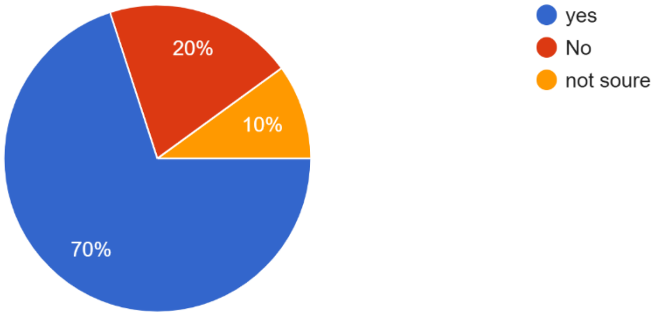
☐ yes

☐ no

Questionnaire pie chart

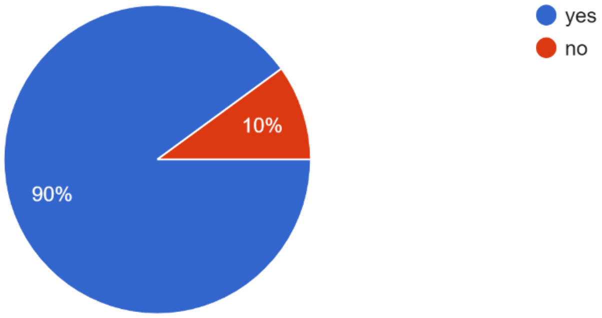
1. Was the lamp easy to understand and use in the first 2 minutes?

10 responses



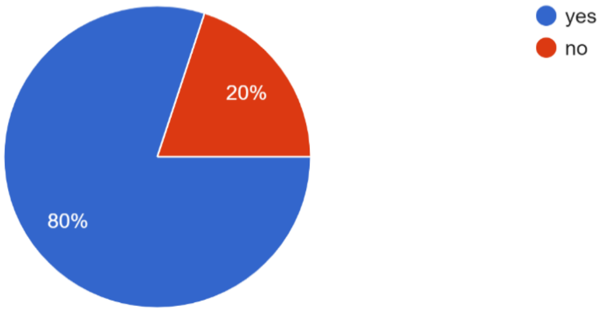
2 Did the telescopic extension feel smooth while using?

10 responses



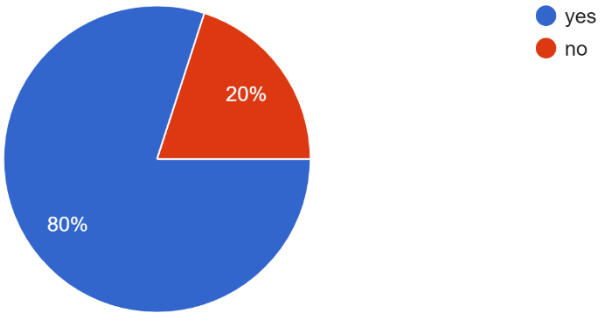
3. Would this lamp be useful in a small room/hostel?

10 responses

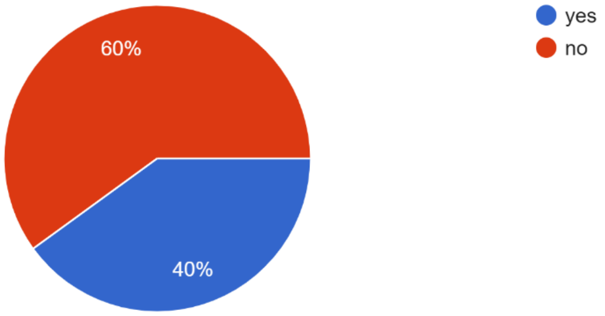


4. Is the design different from your current table lamp?

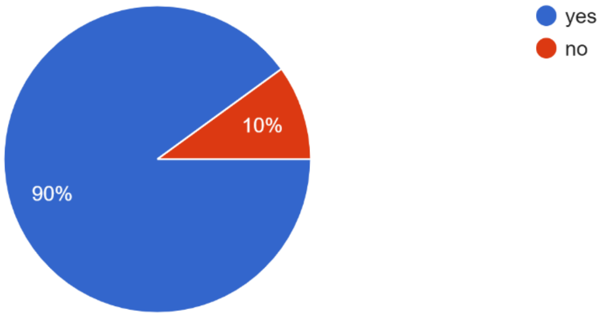
10 responses



5. Did any part feel loose or weak during use?
10 responses



6. Would you recommend this lamp to a friend?
10 responses



Conclusion

This research started from a simple observation - an Oriental hornet, a type of wasp. When you look at its abdomen, you realize it stretches like a rubber band, goes inside in a second, and bends however it wants. Nature has perfected this system over millions of years. For flight balance, to escape from enemies, to handle heat and cold - thousand uses of just one part. Then the question came up that why are the things we use at home so rigid like stone? If you take a table lamp, it is of only one size. If you take a big one it eats up space, if you take a small one the light is not enough. So I learned from the hornet and decided to make a lamp like that. First of all, I downloaded 12-15 videos of the hornet. Watched them in slow motion. Measured with a scale that its abdomen becomes 40% to 50% long. Measured the angle and it bends up to 60 degrees. Wrote all this data on paper. Then sat in the workshop and made a prototype. Took 3 pipes of aluminium. Made so that one goes into the other. Put a ball joint on top so it bends like a neck. Put wire inside, fitted an LED on top. The first model just broke in the hand. The second became heavy. The third time kept the weight under 450 grams and still made it strong. When closed it is 15cm, when opened it is 35cm. Bends up to 90 degrees. Then the real test happened when I gave it to 10 people to use. 5 design students, 3 working people, 2 home users. Gave each one for one week. Then sat and talked to them.90% people said the first thing - "it saves space". One boy lives in a hostel. His table is 2 feet. He said "at night I make the lamp big for study, in the morning I close it and keep my laptop. Earlier there was no space for both". One lady said "at night when putting the baby to sleep I use it as a mood light, bend it towards the wall. In the morning I make it straight for work". Meaning one lamp, but it does 3-4 jobs. Also checked the market. Saw Amazon, IKEA everywhere. There are adjustable lamps. But they only bend the neck.

They don't become short and long. And not a single lamp is inspired by any insect or nature. Meaning what we made is really new. There is a gap in the market. But not everything is good. There are problems too. 3 people did not understand how to open it at first. Said "felt a little scared, will it break". That means we will have to give a small note with the product, or a 30 second video. Second issue - people's trust. We don't trust moving things. This is what we need. What next? 10 more such products can be made. A chair that becomes a bag, a table that goes into the wall. Just have to keep watching. Nature gives a new lesson every day, we bunk the class.

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