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# Programmers' Perspectives on the Use of Previsualization in the Design Process of Three.js Web Animation

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**Abstract:** Previsualization is a visual representation based on computer graphics and 3D animation. It has been a well-known tool in movie-making, used to present, explore, plan, and communicate creative ideas before final filming. The communication aspect of this video-based visualization is a less-explored area, especially in the design and development of programming-based animations. This research aims to understand Previsualization's significance in envisioning script-based web animation. Mixed methodologies were used to gather programmers' perspectives on Previsualization in the process of designing three.js web animation. The research used semi-structured interviews and Likert Scale based questionnaires as data collection tools. The interview data of twelve professional programmers provided their perspectives and thematic analysis provided key inferences. The Likert scale questionnaire obtained programmers' perceptions on the functions of Previsualization and the usability in the context of three.js animation. The study also used quantification to check the central tendency and the collective attitude of programmers towards Previsualization. According to the programmers, Previsualization holds functions of a good visualization and is the best way to prototype animation ideas. It can present a substantial amount of information related to three.js web animation, and it is an effective tool for designers to communicate animation ideas to the programmer. The programmers have high-level acceptance and a positive attitude towards it. They perceived it as more effective than conventional visual representations, such as drawings to present most visual features and prototype script-based three.js animations.

**Keywords:** Previsualization, Web Animation, Programming, Visualization, Design Process

## 1. Introduction

Previsualization is an important visualization tool in movie and animation making. It is animated visuals created using 3D animation software, rendered as a video, a prototype of a shot or sequence which acts as a reference for the final production [9, 18, 19, 21, 22, 30].

Designers use visualizations to present and transfer ideas to the programmers. Previsualization is a digital artefact and an end product, and the programmer is the end-user, so the study of the programmer's perspective helps understand its usability. User studies are important in the art of visualization, so this study is designed based on usability [3]. Qualitative studies such as interviews and usability questionnaires are used to understand the user views.

According to the Hassenzahl model of usability, there can be two different perspectives about an artefact: the designer and the user [12].

A user perspective is about how the user experiences the product. A designer perspective is based on product features and intended product character. A designer's job is to manipulate the product features to provide user satisfaction. Skilled visual designers manage visualizations' perception, cognition, and communicative intent. The user's estimation of usability is based on their perception of effectiveness, efficiency and satisfaction. According to Hassenzahl, "People construct the apparent product character based on the particular combination of product features and their individual standards and expectations" [12].

Product character can be perceived as pragmatic and hedonic. Practical nature is about utility and usability.

Hedonic attributes of a product represent the satisfaction (psychological) the user gains while using the product by fulfilling the goal, such as aid for remembrance, gaining new insights etc. The designer produces a design with specific features such as presentation style, functionalities and content. The designer manipulates the characteristics to provide a user experience, and it is subjective. The concept of "Design thinking", experience design and the HCI set satisfaction as the ultimate goal of any design, international organization for standardization (ISO) mentioned it as a "positive attitude towards the product" [15]. A designer aims to provide clarity in its creation and convey the characteristics appropriately. But the perception of the user is a subjective experience; according to Hassenzahl, "People construct the apparent product character based on the particular combination of product features and their individual standards and expectations." [12].

The focus of the study was to identify the role of Previsualization in the design process of web animation. The researcher's strategy is to comprehend programmers' perspectives about Previsualization in the context of three.js animation.

# 2. Methodology

The study used a mixed methodology. The researcher used data from the semi-structured interview, case study, and usability study that used a quantitative questionnaire with a five-point Likert Scale. It is a psychometric scale, the most widely used approach to scaling responses, assessing attitude and opinion.

This study treats programmers as users, and interviews were conducted as part of the qualitative study. A product has pragmatic attributes that capture the usage and functions of the product; the hedonic details are the psychological reactions of the user concerning the product [1]. Hassenzahl model gives a systematic interpretation to User Experiences, the user's subjective experience while using a product (UX). This model provides the dominant user experience, principles, and concepts that help designers in the design process. A designer produces product features from his perspective; however, it can neglect the user's perspective because they are different from the designer's. The International Standard Organization (ISO) definition of user experience is "a person's perceptions and responses that result from the user or anticipated use of a product, system, service." Designers cannot design or control the user experience, but they can create a better experience for users by applying the insights of the Hassenzahl model.

Visualization is useful only if it is efficient and effective. It should serve the purpose. User studies have an essential role in assessing visualization [3]. A product designed by a designer aims to provide maximum usability and satisfaction to the user; however, designers often fail to deliver satisfying results. The user's appreciation is entirely subjective. The perception of users is completely based on their personal experience. The designer doesn't have control over it. [11]. User studies can provide insights into their preferences and attitudes, which can help to create user-centric products.

## 2.1. Data Collection

This study used different methods for data collection. It included qualitative data based on Semi-structured interviews through open-ended questions and quantitative data based on the Likert Scale. To evaluate the usability, the researchers used a usability assessment questionnaire. Twelve programmers participated in the study. The study gathered primary data from individual programmers working with various organizations in South India. The researcher used purposive sampling to identify participants for the interview. Data saturation is significant in both sample size estimation and qualitative research design. Literature suggests a sample size of a maximum of 12 for in-depth interviews. The diversity of the sample population is achieved by selecting programmers from different locations and based on their relevant professional experience in web technologies. The participant signed a consent and Interview dates are scheduled; Face-to-face interviews are conducted.

The researcher also used a survey based on the Likert scale to collect usability data based on the programmer's perceptions and opinions. The usability assessment questionnaire had a few general questions to understand the current design process, visualization, communication, and opinion about Previsualization. Apart from that, there were two sets of questions, the first set deals with the perceived usability of Previsualization. The second set deal with the perceived functions of Previsualization. The questionnaire was in English and had eighteen questions; all the questions were directly related to the study, and the results were used for analysis. Then users' perceptions were evaluated using a 5-point Likert scale. The questionnaire-based data collection is used as a deductive approach; it involves analyzing qualitative data based on reasoning, a structure that the researcher predetermines. The researcher prepared typical Likert items, starting from Strongly Disagree to Strongly Agree; the choices are arranged horizontally with five evenly spaced levels centred around a Neutral. The participants are allowed to express their ideas in five degrees. The items were arranged based on agreement, ranging from a Strong Disagreement to a Strong Agreement, as shown in the table below (Table 1).

***Table 1.*** *Likert item.*

| Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|

The researcher used the questions as a guide for analyzing the data. This approach is quick, easy and can be used when a researcher has a fair idea about the likely responses from the sample population.

The study used sample animations from threejs.org and Previsualization as a studio component during the research. The researcher created a visualization using the 3D animation software called Autodesk Maya for three.js animation, which is used as visual stimuli.

### 2.2. Analysis

The researcher thematically organized the data from the semi-structured interview. The programmers' views on Previsualization is analyzed to understand its characteristics. The study is in the framework of Knowledge Visualization [7] It explains the role of visual representations to improve the transfer of knowledge [1]. This framework describes the transfer of ideas, generally referred to as knowledge. The study examined Previsualization and the visual communication, knowledge transfer aspects of it in the Knowledge visualization framework. Any communication must have a Sender, message, and receiver. It is assumed that the designer sends a message through the medium of visualization, and the programmer is the receiver.

The Likert scale based quantitative data is analyzed manually using the standard statistical procedure. The mean value is used to compare the overall assessment of Previsualization and the perceived usability. The researcher qualitatively interpreted the data using the following table (Table 2).

**Table 2.** *The Likert Scale range and verbal interpretation.*

| Scale | Range | Response | Verbal Interpretation |
|---|---|---|---|
| 1 | 1.00 – 1.80 | Strongly | Not at all accepted |
| 2 | 1.81 – 2.60 | Disagree | Not accepted |
| 3 | 2.61 – 3.40 | Neutral | No inference |
| 4 | 3.41 – 4.20 | Agree | High |
| 5 | 4.21 – 5.00 | Strongly Agree | Very High |

The results from the semi-structured interview are descriptively narrated. The usability information is presented using charts, and inferences, conclusions are reported.

## 3. Results and Discussion

The script-based animations are a recent, significant development in web animation, and it is a visualization challenge for the designers. This study elicits programmers' perception of Previsualization in the context of three.js animation as a case study. The user perspective of Previsualization and the programmers' views are discussed here.

### 3.1. Semi-structured Interview

Animations from the website three.js were used as visual stimuli during the interview. The researcher requested each participant to identify the communication method required to express the three.js animations and ideas. The programmers expressed that animation ideas could be presented using a combination of Visualizations, Prototypes, Animations, References to express three.js animation effectively. Some of the participants remarked that conventional visualizations, especially images, can't present the ideas effectively. They expect better communication through sufficient visualizations and references.

Experienced programmers can easily understand design ideas from the preliminary representations. A combination of visuals such as drawings, storyboards, animation and step by step instructions can better explain the final design. A Combination of Visualizations will be a good choice. The programmers frequently mention the idea of prototypes; it is created with a storyboard, power points, and 2D animation software. Some of them pointed out references, which is a popular way of conveying messages since the ideas are already there in the visual form. Many programmers expressed those references as an easy way to understand the visual styles. Animation is perceived as a reasonable visualization technique by many programmers; they identified many visual characteristics that it could convey effectively. Animation is helpful to communicate a creative idea with clarity; It includes colour information, orchestration, timing, dimension, and motion.

### 3.1.1. Programmers Views on Previsualization

The researcher introduced sample Previsualization as a visual stimulus to the programmers. The primary question was, "What do you think is the role of the Previsualization in communicating animation ideas?". There are three sub-queries: Feedback on Previsualization, the perceived effectiveness of Previsualization, and the use of Previsualization in projects.

These questions resulted in deeper discussions on Previsualization, and the programmers' perceptions are presented thematically. Their views can be separated into two groups; positive aspects of Previsualization and concerns about its implication.

Positive aspects of Previsualization

*A medium for Prototyping Web animation* - Previsualization can represent the details of the animation, even micro animations as well as an overview of the projects. The programmers perceived animation as a dynamic artefact. An animation is basically a composition that requires staging and organizing of design elements. The programmers perceived that the Previsualization could present the following.

*Representing Design Elements* - According to the programmers, Previsualization helps to present design elements such as shapes, colour, texture and dimensions. The shapes include both two-dimensional and three-dimensional geometries, which are used to present ideas in animations.

*Representing Overall Composition* - Previsualization extends the possibilities of storyboard in storytelling, depicting continuity and representation of the overall composition. It helps to present orchestration (the arrangement of design elements for planning and coordination) and choreography (the designed sequence of movement) better than the traditional visualizations.

*Representing time* - The second significant theme is related to time. The participant expressed it in various ways, via terms like continuity, transition, change, overall duration and timing of design elements.

*Presenting Motion* -The programmers used the term motion in numerous ways to express ideas such as translation, transition and rotation. The animation can prototype Orchestration and choreography in a better way.

*Representation of Depth* - According to the participants, Previsualization helps in-depth perception. layouts, staging and the overall composition.

*Expressing Visual Style and emotion* – Emotion and feeling are significant factors in any design. The programmers perceived that Previsualization could be a medium of expressing the feel of the design. Many programmers call Previsualization a prototype because it offers most of the attributes of the final animation.

The programmers perceived Previsualization as satisfactory, effective and, efficient in visualizing three.js based web animation.

*Programmers' Concerns* - According to many programmers, Previsualization would be considered only for significant projects because of the extra cost involved in producing the same. They perceived that the new workflow would increase project size, cost and time required. Programmers were concerned about reproducing the designs given by the designer using programming. It can be due to a lack of confidence of the programmer or limitation of the programming language. They perceived there is less possibility for prototyping or representing interaction. A constant updating of skillset, technological knowledge, and creative efforts is fundamental to successful design execution. The increase in project duration and limitations of programmer & programming may have an inverse effect on client satisfaction.

### 3.1.2. Discussion

The designers combine many product features such as presentation style, functionality, content, interaction style [11] to a product. Users perceive product features, and their perception depends on the individual and is subjective. As a user, many programmers acknowledged Previsualization as a new idea. The use of Previsualization helps in communication and provides clarity in the message. According to them, it helps in time management, expressing and documenting new ideas. Previsualization helps to present movements and an array of design elements associated with web animation. Many programmers state that it helps in presenting visual style, look and feel, visual depth, texture, colour and aesthetics. So, it is useful in overall visual communication and expressing aesthetics, visual style, composition, and supports in delivering prevailing emotion and feel of the project. The following section discusses different aspects of Previsualization identified during the study.

*Previsualization: as a Medium,* it is created using computer graphics; the output is in the form of a video. 3D computer graphics are more functional than conventional videos, but creating this "Synthetic imagery" is time-consuming [20]. 3D Animation is significant in movies, computer games, advertisements and other time-based media; thus, it has an important role in the current visual culture. Video as a medium for visualizing and communicating design ideas is a very recent development in design. Now videos are an essential source of information and a medium of choice for many.

*Previsualization and presentation of motion* - Web animation involves designing and visualizing motion. The programmers expressed various aspects of it using terms such as continuity, temporality, transition, change and rotation. Previsualization is relatable to motion design and graphics. Motion is a design element and potential language with a grammar for how users perceive, feel, and respond [27].

*Presenting time and sequence* - Previsualization as motion graphics helps to present concepts and composition changing over time [26]. The programmers expressed themes such as duration and length prediction related to time. Animations can be called interactive visualization; they present changes over a period [1]. It aligns with the view of Chang that Animation provides the visual cues necessary to understand what is happening before, during, and after the action [2]. A visual presentation through animation is very important. In his book "The Theory and Practice of Motion", Brian Stone argues that motion design involves orchestration [27]. A motion designer creates harmony across a sequence of images [26].

The art of motion graphics creates mystery and certainty. The artforms such as animation and movies effectively use dramatic events that fascinate the minds. The content of Previsualization is not meant to create mystery but to communicate certainty or represent the subject matter and ideas. Previsualization usually does not require complex compositions used in recent digital movies [26].

*Depth perception* - Programmers perceived that Previsualization helps understand depth better than traditional visualizations. 3D animation tools allow the visualization of three dimensions and produce a video that shows virtual environments unfold in time and provide a new experience [5].

*Hedonic Component* - The programmers used the terms like Emotion, Feeling, Happy and Satisfaction to express user experience. They perceived Previsualization as a vehicle of visual style that can present emotions. According to Bowers, emotion is a powerful aspect and component of design as in life. Feelings can be positive or negative. The designer can use design elements like form, colour, visual juxtaposition to invoke emotions in the user. On Stones account, "A design strategy can form an emotional connection with a viewer to elicit a specific response", and motion design should "stimulate the senses, trigger emotion, hold our attention, and enhance understanding." [27]. The design of Previsualization is not only a technical process, but also it should convey the message of science and emotion.

*Previsualization:* As the prototype - The participants frequently mentioned the word prototype. They consider Previsualization as a visual, digital and virtual prototype. This point can be related to Hartmann's view on a prototype. Prototypes are "approximations of a product along some dimensions of interest" [10]. The prototypes used in recent design disciplines, such as interaction design, are considered a subset of visualizations. [13].

Designers use simple, low fidelity prototypes such as drawings for design thinking and ideation. These prototypes help the intra-personal (self-communication) and interpersonal communication for them. Prototypes are beneficial for both communication situations. A simple

drawing is an essential tool in design thinking during the design process. A drawing can be a prototype even if it does not present all the final design features [28].

Previsualization has visual similarities to the final output of three.js animation. As a dynamic visualization, it can present visual elements of script-based animation and helps to identify the objects. [23]. According to the Design Council, the prototypes help designers and multi-disciplinary teams to understand the concepts and act as a point of reference for further discussion. It helps in defining and refining ideas through reviews and finding solutions. It also helps in interpreting user needs [4]. It helps in visual management by tracking the evolution of the project. The design firms use prototyping techniques at various levels in the design process to reduce cost and time [4]. Instead of physical models, some companies are using computer simulations, known as virtual prototyping [31].

Previsualization does not present all the features of the final web animation. In Jenson's view, "prototypes are not production stage design" [17], which means prototypes need not necessarily reflect all the properties of the final design. According to the Design Council, prototypes can be used to test concepts, demonstrate the potential of the final artefact, use as a reference for discussion and a tool for getting feedback [4]. Vosniadou explains the theory behind the use of prototyping. According to him, "The ability to perceive similarities and analogies is one of the most fundamental aspects of human cognition". [29]. Previsualization offers a solution for visualization, which showcases the ability of a prototype more than a drawing. Compared to other visualizations like drawing, the output of Previsualization is more didactic; it can describe refined details.

*Summary of responses* - The programmers' feedback provides insights on Previsualization's competencies and qualities and concerns regarding its use in the design process. According to the programmers, visual representations are the best way of representing three.js animations. They prefer a combination of visualizations, prominently visual prototypes or references based on animations to communicate the ideas effectively. The programmers expressed more competencies of Previsualization than concerns about it.

They perceived that Previsualization saves time by effectively intervening in the project. It can present motion, temporality and visual style aspects such as texture and color. It can also articulate the overall look and feel, details, overview and communicate the emotional element of the design. The clear presentation of all these aspects will reduce the communication gap among the team, especially in complex design situations.

Previsualization helps to present considerable visual ideas and most of the design elements that are part of web animation. The programmers perceived that Previsualization can facilitate or represent many aspects, including design elements of web animations. The following table (Table 3) lists the design characteristics that Previsualization can carry as perceived by the programmers.

*Table 3. Design characteristics and Previsualization.*

| Design characteristics | Overarching concepts |
|---|---|
| Shape, 3D Geometry, Colour, Texture, Dimension (length, Width, Volume), depth, visual style | Design Elements |
| Duration, the timing of the animation | Time |
| Translation, Transition, Rotation, Scale, Zoom, Movement, Change | Motion or Change |
| storytelling, Continuity, Transition, layout, composition Sequence, Planning | Orchestration/ Choreography |
| Emotion | Emotion |

Previsualization can present considerable visual elements, such as motion, visual style, look and feel, project details and overview, visual depth, timing, emotion, orchestration and choreography. It is expected to improve time management, communication and thus the overall satisfaction of both the team and client. It suggests that Previsualization can facilitate better communication among designers and programmers. It can be a reasonable visualization choice for designers in programming-based web animation.

The programmers' views consist of practical and hedonic (emotional) aspects. The overarching concepts show that the users perceived both practical and emotional elements in Previsualization. They perceived it as effective, efficient and satisfactory. It is a complex and practical visualization that is easy to understand and comprehend. It is a manageable and straightforward technique that uses the latest technology for visualizing. It also supports a clear and organized presentation of animation ideas to predict the outcome of script-based web animation. It integrates the design process, bringing all the stakeholders closer due to its presentation style and usability.

The programmers have expectations on an ideal visualization [16]. According to programmers, a visualization should help in communication, present design elements, represent motion, store and transmit knowledge, reduce the communication gap, help in time management, and present the design visualized by the customer. The perceived qualities of Previsualization are sufficient in addressing the visualization of three.js web animation.

The programmers expressed a few concerns also; it is mainly due to an increase in project size and cost due to the implementation of Previsualization. The programmers agree that Previsualization can be valuable in significant and complex projects. This statement supports Schrage's remark "when the cost is not as high, and that prototypes help facilitate communication" [25]. On the other hand, some programmers feel the animations as presented by Previsualization are sometimes unachievable. They might require additional support to fulfil the design. All these factors might affect the outcome and the clients' satisfaction adversely.

Furthermore, the programmers are less convincing about Previsualization's ability to represent interactivity, a crucial

element of script-based web animation. A prototype should address the look and feel, role and testing of the original idea, if not entirely, at least one design element [14]. Previsualization is a prototype that addresses all these aspects to some extent.

### 3.2. The Programmers Responses Through Questionnaire

The Likert scale is used to measure attitudes and opinions with added accuracy. This study intended to gather data based on the perceptions of the programmer in the context of the design process of three.js 3D web animations. The scale is planned and prepared using the information obtained from the previous studies and the literature on Knowledge Visualization. It is also used to gather more information to corroborate the previous interviews.

The participants assessed a set of positively voiced statements in a usability assessment questionnaire. It started with a few general questions, such as the most frequent communication method of animation ideas used by the designers to a developer. The participants are allowed to express their opinions in five degrees, the most frequent to least frequent according to the priority. The statements were prepared based on the review of the literature and expert interviews.

A list of statements was used to find programmers' attitudes towards Previsualization. Likert items were used to identify how strongly they agree or disagree with the statement, and positive or negative orientation towards the statement expresses their perception about Previsualization. There are fifteen statements (Stmt:1 to Stmt:15) classified into two categories. The first set deals with the perceived usability of Previsualization, while the second set deals with the perceived functions of Previsualization. This section is designed to check whether Previsualization fulfils the functional aspects of visualization based on Knowledge Visualization [7].

### 3.2.1. Programmers' Reaction to the Statements

The study identified five communication methods based on visuals: images, Storyboard, PowerPoint presentation, 2D Animation and reference websites. The results show that industries use all these presentation techniques almost equally. Perhaps the most frequent references are 2D representation and reference websites. Further responses from the programmers indicate that the most preferred visualization tool is also 2D animation.

The first set of statements is used to identify the usability aspect of Previsualization. The programmers perceived a high to a very high level of confidence in presenting micro-animation, UI animations, look and feel of animations, and 3D web animations using Previsualization. The programmers think that Previsualization is very efficient, and it helps in understanding animation ideas more efficiently than conventional images, storyboards and other visual representations. They have a high level of confidence in perceiving animation ideas through Previsualization. According to programmers, Previsualization is very effective, and it helps in the communication of animation ideas more effectively than conventional images, storyboards and other visual representations. They show a very high level of confidence in Previsualization. The programmer's perceived less or no confidence in presenting a non-interactive user interface using Previsualization.

The second set of statements was used to elicit information related to the functionality of Previsualization. Table 4 shows the functionalities and range of agreement in percentage.

*Table 4. Perceived functions of Previsualization.*

| Sl. No | Functions of Visualization | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|---|
| 1 | Coordination | 0% | 0% | 8% | 25% | 67% |
| 2 | Engagement | 0% | 0% | 8% | 50% | 42% |
| 3 | Remembrance of Design Ideas | 0% | 0% | 25% | 25% | 50% |
| 4 | Encouragement | 0% | 17% | 33% | 25% | 25% |
| 5 | Expressing Ideas | 0% | 0% | 0% | 42% | 58% |
| 6 | Representing New insights | 0% | 8% | 0% | 50% | 42% |
| 7 | Consensus | 0% | 8% | 17% | 58% | 17% |

It is noticed that 50% of programmers are aware of video-based visualizations, but it is a rarely used visualization technique in the process of designing web animation. The programmers have a high to a very high level of confidence about Previsualization and its ability to support coordination among the team, to engage the team in the design process, and support the remembrance of design ideas. Programmers show a high level of confidence about Previsualization's ability to encourage team individuals, communicate design ideas, and present new ideas. According to them, Previsualization helps create consensus among the team and reduce the communication gap among the team.

The following section organizes and summarizes the characteristics of the whole data set; the collection of responses from the participants to understand the central tendency. It is a descriptive summary of a dataset through a single value that reflects the center of the data distribution.

The comparison of the overall assessment of Previsualization and its perceived satisfaction is explained below. The subjective opinion about Previsualization and the overall impression about it are examined. The perceptions of the programmers are considered as indicators of usability. The following tables illustrate a descriptive summary of the major sentimentality of the participants. Table 5 presents the perceived usability.

The respondents rated the statements regarding the usability of Previsualization in the Usability questionnaire with a mean rating from 3 to 5. Thus, it can be inferred that Previsualization has an overall positive rating on usability.

The table 6 presents the perceived functionality of Previsualization.

**Table 5.** *Perceived Usability.*

| User Statements Regarding… | | Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5) | Mean |
|---|---|---|---|---|---|---|---|
| …. The effectiveness of Previsualization | | | | | | | |
| Previsualization helps in | representing micro animations (Stmt:1) | 0 | 1 | 0 | 9 | 2 | 4 |
| | interactive User Interface animations (Stmt:2) | 0 | 0 | 0 | 7 | 5 | 5 |
| | non-Interactive User interface (Stmt:3) | 0 | 5 | 3 | 3 | 1 | 3 |
| | overall look and feel of animations (Stmt:4) | 0 | 0 | 3 | 3 | 8 | 5 |
| | 3D web animation (Stmt:5) | 0 | 0 | 6 | 6 | 3 | 4 |
| …. The efficiency of Previsualization | | | | | | | |
| Previsualization helps in | understanding animation ideas more efficiently than the conventional representations (Stmt:6) | 0 | 0 | 1 | 2 | 9 | 5 |
| | communicating animation ideas than the conventional representations (Stmt:7) | 0 | 0 | 2 | 3 | 7 | 5 |
| …. The user satisfaction | | | | | | | |
| Previsualization helps in | reducing communication gap (Stmt:15) | 0 | 0 | 1 | 9 | 2 | 4 |

**Table 6.** *Perceived Functionality.*

| User Statements Regarding… | | Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5) | Mean |
|---|---|---|---|---|---|---|---|
| …. The functions of Previsualization | | | | | | | |
| Previsualizations helps in | coordination (Stmt:8) | 0 | 0 | 1 | 3 | 8 | 5 |
| | engagement (Stmt:9) | 0 | 0 | 1 | 6 | 5 | 5 |
| | remembering design ideas (Stmt:10) | 0 | 0 | 3 | 3 | 6 | 5 |
| | encouraging emotionally (Stmt:11) | 0 | 2 | 4 | 3 | 3 | 4 |
| | explaining designs and ideas (Stmt:12) | 0 | 0 | 0 | 5 | 7 | 5 |
| | representing new insights (Stmt:13) | 0 | 1 | 0 | 6 | 5 | 5 |
| | creating consensus (Stmt:14) | 0 | 1 | 2 | 7 | 2 | 4 |

The respondents rated the statements regarding functions of Previsualization in the Usability questionnaire with a mean rating from 4 to 5. The inference shows that Previsualization has an overall positive rating on its functions as a visualization technique.

The participants show a high level of agreement towards coordination and representation ability of Previsualization.

Comparatively less importance to its ability to make consensus among stakeholders, but data shows it is still a very effective way for communication. The following stacked bar chart visualize the data (Figure 1).

Previsualization showcases all the functions of a visualization. The programmers have a very high level of agreement with these statements related to the functions.
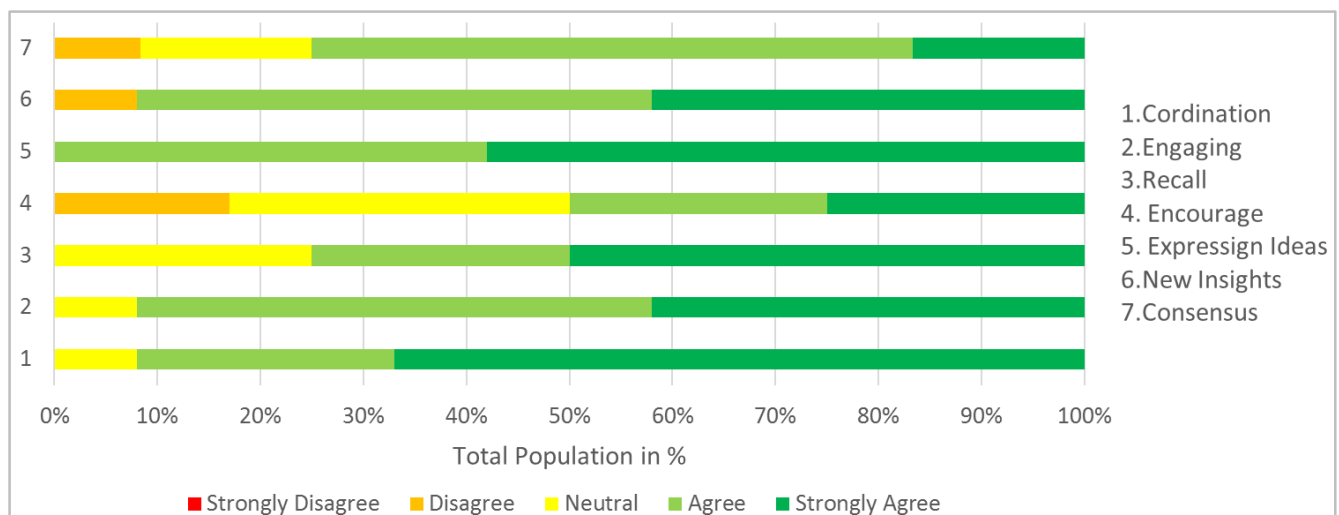


**Figure 1.** *The Perceived functions of Previsualization.*

### 3.2.2. Discussion

According to the programmers, the current design process often uses 2D Animation and existing animated websites as a reference. They expressed 2D animation as the most preferred medium and images as the least preferable one to present animation ideas and as a visualization tool. The majority of the

population (92%) agree that Previsualization helps represent Micro Animations. All the participants agreed that Previsualization is useful in representing Interactive User Interface Animations. In the case of the Non-Interactive User Interface, there are mixed reactions, and most programmers have negatively rated the statements; 42% of the population disagree with the statement. Most of the programmers (92% positively evaluated) agree that Previsualization is useful in presenting Animations' overall look and feel. A total of 75% agree with the statement that 'Previsualization is useful in visualizing 3D web animation'.

The programmers' perceptions are outlined here,

It helps to coordinate (synchronizing) among the team members, especially between the designer and the developer.

It is more engaging and eye-catching than other frequently used design representations.

It helps in remembering design ideas.

To some extent, it encourages programmers emotionally.

It helps in explaining designs and ideas.

It helps in perceiving ideas and gathering new insights.

The participants show a positive attitude towards the visualization technique and express no significant disapproval towards its functions.

The following diverging/bidirectional stacked bar chart (Figure 2) shows the overall responses. Agreement on the positive side and disagreement on the opposing side. Neutral responses are arranged on the negative side, as it is not considered as satisfaction. It helps to compare the data visually.

Data shows Previsualization has a very high level of acceptance among programmers on functions like coordination, engagement, expressing and remembering design ideas. Previsualization encourages the programmers, and it helps explain concepts to enhance creativity, and programmers showed a high level of acceptance to the statement.

The programmers expressed a high agreement towards the statement, "Previsualization helps create consensus among the team or between the designer and developer". It helps in reducing the communication gap among the design team than the existing visual representation methods. Many programmers have already experienced visualization in the design process. Half of the sample population received 3D animation or video-based visualization to support their project.

In the Knowledge Visualization framework, the function type category suggests the overall application and the qualities a good visualization. Two Likert scale responses, i.e., Agree and Strongly agree, combined, show positive feedback. Hence it suggests that programmers perceived Previsualization as an effective visualization technique in the design process of web animation.
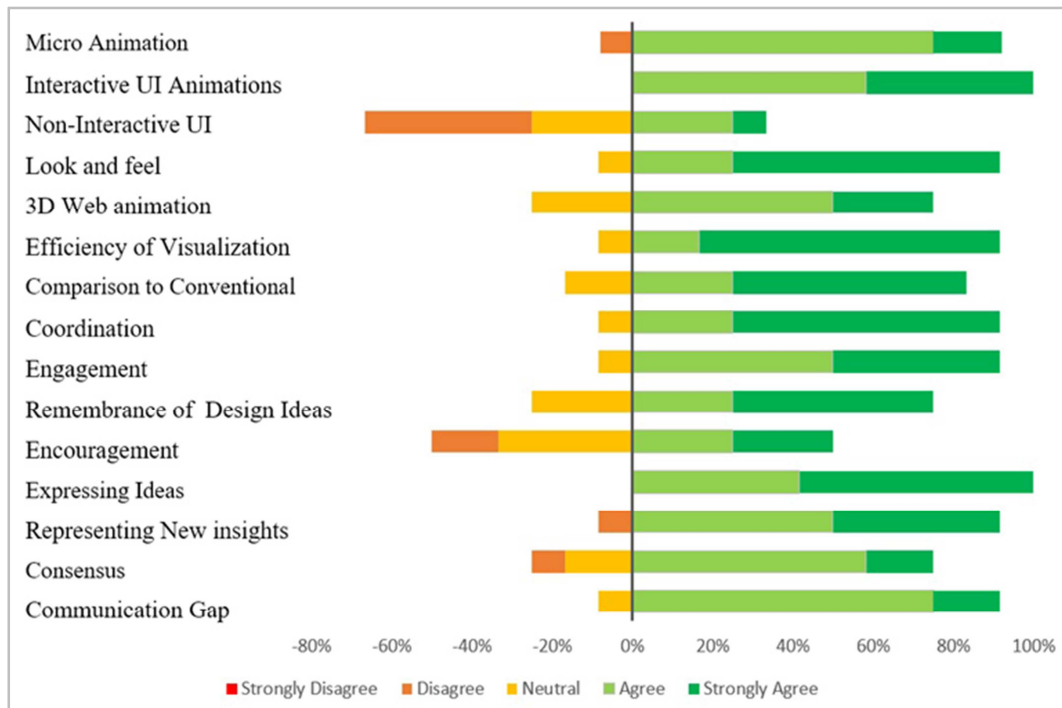


*Figure 2. The overall attitude towards Previsualization.*

Perception is important for humans; our perception backs the knowledge about the environment and our existence. As Locke remarked, acquiring knowledge through our senses is casual and natural. Many researchers explained how important it is to externalize ideas through sketching and other means to understand problems and generate new ideas [24, 8]. The overall ideas related to visualization is aligned to the idea of Fallman, that "the act of externalizing an idea onto some medium often results in the generation of additional ideas as they become more concrete" [6]. Visualization must be user-centric, context-specific and the knowledge transfer can be improved by combining visualizations.

# 4. Conclusion

Programmers prefer visualizations, prominently visual prototypes or references based on animations which communicates the design ideas effectively. Previsualization can present visual ideas and most design elements of three.js animations, including motion, temporality, and visual style. It can integrate the design process by bringing all the stakeholders closer due to its presentation style and usability. It may increase the project size, cost and time involved. The majority of the programmers perceived that Previsualization helps to understand animation ideas more efficiently than conventional images, storyboards and other visual representations. They consider it more effective in communicating animation ideas than traditional visual representations. Programmers perceive a high level of confidence in representing Micro Animation, Interactive User Interface (UI), overall look and feel of Animations and 3D web animation using Previsualization. They perceive it as efficient and effective in communicating animation ideas than conventional images, storyboards and other visual representations. Programmers are less confident in representing Non-Interactive User Interface using it.

The results from the questionnaire show a positive correlation to the early inferences from the interview. Previsualization has an overall positive rating in terms of usability, and it holds all the qualities and functionality of a good visualization. Programmers show a high level of acceptance towards Previsualization, and perceive it as an effective representation technique for web animation since it fulfils all the functions of an ideal visualization.

The insights from the study extend the knowledge base of visualization and recommend Previsualization in design situations such as programming-based web animation. The research confirms the practice of visualization and its effectiveness in communicating ideas while designing animation. The visual representations are central to developing designs since it prototypes visual concepts, and they can support designers and other stakeholders in different stages of the design process. Future work opportunities include investigating the influences of Previsualization in different design scenarios, especially prototyping programming based virtual environments and animations.

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