Digital Visualization in the Teaching of Cognitive Visualization

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Abstract
Professional design offices claim that our graduates have difficulties with their free-hand perspective drawing skills. This fact, which has become obvious over the last 5 years, is parallel to a clear tendency towards the use of 3-dimensional digital imagery in the projects of our students. Frequently, faculty tends to blame the computer for the shortcomings of our students in the use of traditional media, yet there is no clear evidence on the source of the blame. At a more fundamental level, the visualization skills of our students are questioned.

This paper will explain how faculty teaching design communication techniques, with traditional and digital media, are working together in the development of a teaching methodology that makes use of computers in support of our student's training on cognitive visualization skills, namely; "*The Third-Eye Method*". The paper describes the Third-Eye Method as an alternative to traditional methods. As evidence of the benefits offered by the Third-Eye Method, the paper presents the results of testing it against traditional methods among freshman students. At the end, the paper draws as conclusion that computers are not the main source of the problem but a potential solution.

Keywords
Pedagogy, Visualization, Media

1 Introduction

In 1999, Architectural Record Magazine (Mitgang 1999) conducted a survey among architectural design firms with the objective of determining whether academia was providing the profession with a relevant work force. Based on the comments of the interviewees, it was clear that our students were rapidly mastering the use of digital media but at the same time they were losing ground on the use of traditional media. This was no surprise for professors teaching upper level design studios. Over the last 5 years this trend has become very obvious. Our students are making more use of CAD and less use of the drawing table and sketchpad.

Because of the simultaneity of these two phenomena, we have developed the unsubstantiated belief that digital media and traditional media are in conflict. We have transferred the old paradigm of mass media, in which television came to undermine the use of radio, to architectural media, in which digital imagery comes to undermine the use of hand drawing. Our research has the objective of questioning such a belief and demonstrating that as with the case of television and radio, digital media and traditional media are not necessarily in conflict. It is a fact that we will continue to listen to the radio as we drive to work every morning and in a similar way we will continue to produce fast freehand perspectives as we converse with our clients.

It is a fact that at Texas A&M University we have a large and growing number of students that lack the strong free-hand perspective drawing skills that previous generations of students had. We are not currently concerned with the magnitude of this problem at national or international level nevertheless; we can safely assume that Texas A&M University is not alone in identifying this problem.

We are not making reference to the ability of our students to produce hard-line orthographic drawings by hand. This is a practice that has been largely replaced by the use of CAD not only in academia but also in the profession. We are making reference to the inability of our students to produce fast, yet credible free-hand perspective drawings during desk critics or in early stages of schematic design. This is a skill that we need to preserve as it closely relates to our ability to design.

Our cognitive visualization skills, frequently addressed as our "third eye", are fundamental in our ability to design (Kepes 1944). They are also critical in our ability to draw. Young children with good cognitive visualization skills, some may say talent, can draw 3-dimensional imagery directly from their cognitive source without any analytical elaboration or understanding of how a perspective works (Figure 1).

Later as such children are instructed on the analytical fundamentals that rule the generation of perspective drawings they can refine their technique and continue to produce outstanding work.

In architecture we draw what we imagine and it should be possible for us to do that without having to go through the process of translating 3-dimensional imagery into 2-dimensional orthographic drawings so that we may apply analytical perspective drawing methods (Antoniades 1990). Our hypothesis is that our students cannot draw because they cannot image. In other words, their third eyes are not working.

Figure 1. Three-Dimensional drawing made by a 5 year old child with no perspective analytical knowledge or training.

2 What is going on in the Academic Environment

In the academic environment we find difficulties addressing two sets of variables that have a direct impact on what and how we teach. In the first set we find the liberal arts paradigm of offering an education versus the technocratic paradigm of offering effective training. In the second set we find the contrasting philosophies of teaching how to design at the interior of each one of the courses, against the one of applying what has been learned in all our courses within the design studios. Our approach to the teaching of design and design media depends on where we stand in relation to these paradigms and philosophies.

2.1 The Teaching of Traditional Media Courses

Traditionally, schools of architecture offered a series of drawings courses in which students were instructed on the creative use of analogue media. In other words, design was part of the content of the course even if the students were graded mainly on the basis of their control of media. As recently as 30 years ago a typical curriculum in architecture was expected to feature courses in freehand drawing, perspective drawing, rendering techniques, and even art courses such as sculpture and painting. Today many architecture curricula do not offer drawing courses at all under the assumption that the student will pick up graphic skills in the design studio. More common is a single drawing course with concentration toward learning the drawing conventions, perspective, orthographic drawings, paraline drawings, etc.

At Texas A&M University we have followed this process and today we offer a single drawing course responding to a technocratic paradigm in which the students are trained in traditional graphic techniques. At the same time, applied design has been encapsulated in the design studios with the hope that they will somehow serve as a creative melting pot of all the technical skills offered in tributary courses. On balance, we may say that through time a generous number of traditional media courses, that addressed design within their own framework, have been substituted by a single course that due to time constraints needs to concentrate on teaching essential drawing techniques.

2.2 The Teaching of Digital Media Courses

In a very different time scale than traditional media, the teaching of digital media has evolved in an opposite combination of paradigms and philosophies. Originally, schools of architecture offered very few courses on digital media and in most cases these were elective courses that trained the students on programming skills that were largely dissociated from design applications. More recently, we find that digital design media has claimed at least one required course in most architectural curricula and that the content has migrated from the technocratic approach of teaching programming to the more creative approach of applying digital processes in support of design tasks within the course itself.

At Texas A&M University our course on digital design media has grown from being a single section course in the second year of the curriculum, to become a four sections course of the first year. The course is a threefold split in which the students are educated on the fundamentals of computing, are trained on the operation of computer programs, and are offered practical opportunities for using digital media in design assignments (Vásquez de Velasco and Clayton 1999). On balance, we may say that through time a very limited number of digital media elective courses, that hardly addressed design issues, are being offered and have been substituted by required courses that are making use of on-line teaching resources. These courses can afford to educate, train, and offer creative application opportunities.

2.3 The Teaching of Design Studios

It is a fact that design studios offer excellent opportunities for the teaching and learning of design media, both traditional and digital. In terms of evolution we have moved from times in which students were not allowed to use computers in design to a more balanced and opportunistic use of media. At this point in time, probably the most common position is to suggest the use of traditional media in early stages of design and digital media in the development of project documentation.

At Texas A&M University most of our studios maintain the philosophy of using media on an opportunistic basis but this does not mean that

traditional and digital media are used evenly. Traditional media are being completely eradicated from the stages of product documentation at the same time that the students move into the use of digital media at an ever-earlier stage in the design process. This tendency, combined with pressure towards the delivery of high-impact project presentations (that will find their way into student and teaching portfolios) is limiting further the application of traditional media in the design studios.

2.4 The Root of the Problem

Our abilities to imagine and represent are interdependent. In the past, our students had adequate support for learning how to produce analytical perspective drawings and sufficient opportunity to practice such a skill within their drawing courses and design studios. It must be noted that in order to produce an analytical perspective we need to transfer our design decisions, which are essentially 3-dimensional, into 2-dimensional representations upon which we may apply an analytical perspective method.

The repetitive exercise of drawing analytical perspectives stimulated our ability to visualize more complex imagery and at the same time facilitated its representation. In this process, our students were finally able to visualize environments with such a level of completeness as to allow them to produce fast representations that came to be the synthesis of their imagined objects and not a laborious analytical deduction of their representation.

The problem we have today is that our students do learn how to produce analytical perspective drawings but lack the opportunity to practice the skill. On the one hand, single drawing courses cannot afford the luxury of repetitive exercises of drawing analytical perspectives, and on the other hand our design studios profess a philosophy that dictates opportunistic use of media. Within such a philosophy, if a student has already translated his/her decisions into 2-dimensional representations, usually in CAD, it is easier to produce a 3-dimensional digital model of it than to use the same 2-dimensional representations for the production of a single analytical perspective. The bonus is that as son as the 3-dimensional digital model is ready we can produce accurate perspectives from a large number of viewpoints in very little additional time.

If we analyze the content of our traditional and digital media courses we will find nothing that targets the development of cognitive visualization skills among our students. It is our educated guess that our current students are not less talented that their predecessors and that their notorious drop on drawing skills is the result of limited opportunities for training their "third eyes" (Romiszowski 1990)

We need to develop a method through which we may target the development of cognitive visualization skills among our students and by doing so promote their ability to produce fast freehand perspective drawings. We are aware that practice in drawing is directly related to our ability to imagine and that our ability to imagine will feedback into our ability to draw (Laseau, 2000). We need to develop the equivalent of a "drawing treadmill" in which our students may find means for accelerating the training of their "third eyes" and improving their ability to draw.

3 The Third-Eye Method

The Third-Eye Method makes use of 3-dimensional modeling software and visualization techniques for training the student in the execution of very fast cycles of visualization and representation. It targets directly our ability to imagine, and to draw what we imagine, bridging over analytical drawing conventions. The computer offers information in the visualization framework and immediate feedback on the improvement of student's cognitive visualization and representation. The Third-Eye Method is implemented through a simple exercise that can be best described by the following process:

1) The student is asked to produce a simple (or complex) composition of 3-dimensional geometrical primitives using the application program 3-D Studio VIZ.
2) Once the composition/model is produced, the student is asked to introduce the presence of a "*target camera*", making use of the orthographic view port. The target camera can be manipulated into position as the student tries to image the resulting perspective.
3) The student is asked to use a small sketchpad for drawing a fast free-hand perspective of the predicted view.

Note that the student is not asked to apply analytical drawing methods.

4) The student is asked to activate the view port of the target camera and compare the actual perspective with his/her drawing in the sketchpad. (Figure 2).
5) The student is asked to make fast corrections on the drawing.

The 2) to 5) step process can be repeated a large number of times in a small period of time. Once the students fully understand the initial 3-dimensional environment they are asked to add more objects and increase the complexity of their nature. This will be followed by a new set of 2) to 5) step processes. At the end, we expect that the student will be able to imagine with substantial accuracy the "target camera" views and predict them by means of fast free-hand perspective drawings.

The Third-Eye Method can articulate a number of 2) to 5) step processes with different levels of complexity in both the deployment of cameras and prediction of the resulting perspective views.

3.1 Experimentation

With the objective of testing the effectiveness of the Third-Eye Method, during the spring of 2001, we implemented the method at experimental level. The group tested was a section of ENDS115 students in the College of Architecture at Txas A&M University. This class is the "Design Communications" course offered in the Environmental Design Curriculum. The aim of the course is the introduction to and practice of tools, methods, and techniques, available for graphic communication of architectural designs; observation and other forms of free-hand drawing and drawing systems which develop the student's representational and descriptive capabilities. Insofar as it is the only course that specifically addresses drawing for its own sake, it is wide-ranging and intensive.

Figure 2. The computer offers instant feedback on the level of accuracy achieved in the freehand perspective drawing.

The particular group tested was an "honors" section, which usually indicates an above average level of acuteness. Nevertheless, most of the students had little or no formal drawing experience before taking this course. Further, this exercise was administered during the 4th week of classes so that the only exposure the students had to perspective per se was as attendant commentary during free-hand sketching sessions.

The class of 17 students was subdivided into two randomly chosen groups. The only demographic considered was in dividing male and female students equally. The idea was to train one group of 9 students following traditional methods at the same time that the other group of 8 students was trained by means of the Third-Eye Method. The two training sessions were simultaneous and lasted about 3 hours. The ENDS115 professor of record managed the group making use of the traditional method. The ENDS270 professor of record managed the group making use of the Third-Eye Method.

In contrast with ENDS115, which concentrates in the use of analogue design media, ENDS270 concentrates in the use of digital media. It offers an introduction to the history of computing; it deals with the fundamentals on computer applications for design, planning, and construction; it reviews applications for management, network publishing, vector editing, raster editing, modeling, rendering, animation, multimedia / hypermedia presentations, telematics, and the development of virtual environments.

Both professors have extensive experience in the use of design media and have similar rapport with the students. The instructors agreed upon the configuration of objects to be used in the training sessions.

3.2 Training with Traditional Methods

Teaching a drawing type, which instills in the student an understanding of perspective space, involves, choosing from several possible methods. The desired effect is that the student can draw objects such that those objects are measurable and rational in their placement and proximity. The one point perspective grid was chosen because of its relative simplicity, most the students grasp the concept quickly. With a grid the user can easily place objects in space, as one might place pieces on a chessboard. The disadvantage of the one point grid is that because of the single diminishing direction (as opposed to two or three), the view is more restricted than with say, a two-point method.

- In teaching the one point grid method, we assumed a three-hour session to be sufficient for a working skill level. The grid itself is relatively easy to learn once the student grasps the use of the diagonal point (also "measuring point") and develops an idea of how heights are determined. A lecture/demonstration and an hour of hands on practice will typically give the student enough dexterity to function.
- In the Traditional Method group, the students were shown a plan view of the configuration of objects on the grid (we called it a "top view, as this was also their first exposure to orthographic projections"). A "viewpoint" arrow was placed on the plan view (this was on the board at the front of the class as well as in a handout provided) (Figure 3).
- They were asked to make a guess on a sketchpad predicting how they though the view would appear. This took only few minutes. Then the students were asked to construct the view on a one-point grid as a "check". A total of 4 viewpoints were given, which was about the limit in the 3 hours session since they literally constructed the grid each time they check their guess. The advantages and disadvantages of this procedure are discussed below.

3.3 Training with the Third-Eye Method

The group of students that was to participate in the computer based training session was asked to report to one of the university computer classrooms and to bring a small sketchpad. Each student was handed a floppy disk containing a 3-D Studio VIZ file. In the file they found the same configuration of objects offered to the students using the traditional method. The configuration of objects was displayed on top, front, side, and perspective view ports (Figure 4).

Surrounding the configuration of objects, the students could see the deployment of 4 "target cameras". Half an hour was dedicated to show the students the most basic commands of 3-D Studio VIZ and immediately after they were asked to start sketching a prediction of the perspective view offered by the first camera. Once they finished their first sketch they were allowed to change the perspective view port into the perspective view of the first camera and to compare their drawings making corrective annotations on top of their sketches.

Due to the fact that the computer was able to offer immediate feedback on how the perspective view of the individual cameras should look, the students were able to complete their 4 first sketches in about 30 minutes. Following that initial set of sketches, the students were asked to spend 90 minutes deploying additional cameras and trying to predict the actual views by means of

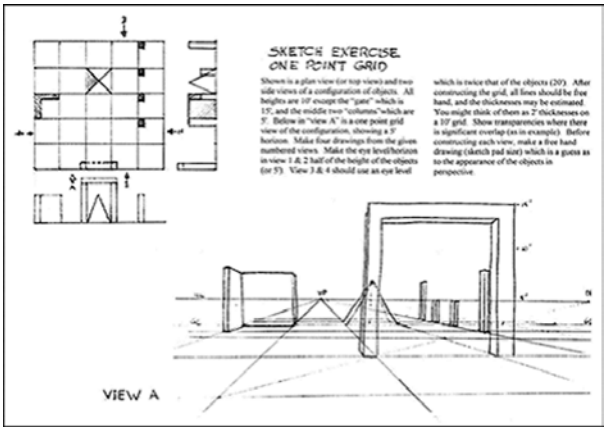

Figure 3. Handout used in the application of the "Traditional Method".

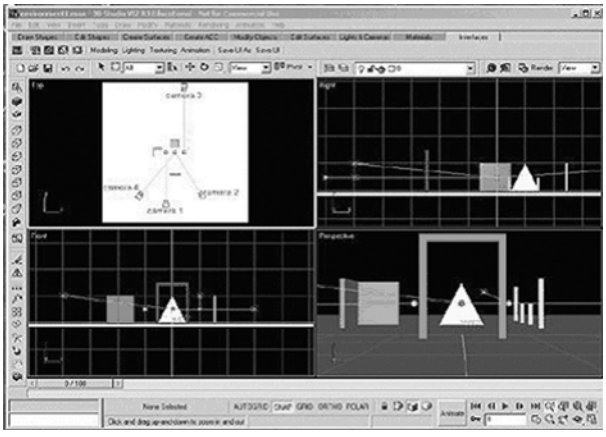

Figure 4. Front-end screen used in the application of the "Third-Eye Method"

their sketches. Most students produced between 12 and 20 fast free hand perspectives during those 90 minutes. During the last 30 minutes, the students were asked to add more objects to the environment and continue to deploy more cameras.

3.4 The Testing Session

The following class day the students were back together. They were given a handout that included four computer printouts showing orthographic information and a paraline view of a configuration of objects that was slightly more sophisticated than the configuration used in the training sessions (Figure 5).

The plan view of the same was drawn on the board. They were given 6 consecutive viewpoints and asked to, again, guess on their sketchpads how they thought the views would appear. They were given about 5 minutes per view so that the entire testing session only took about 45 minutes. In addition, the students were asked to produce a last sketch from a viewpoint of their choice. The drawings were taken up and evaluated.

The following class period the groups were reversed so that each student was exposed to both training types. Finally, they were asked to comment upon the experience. Some typical responses are sited below:

"I think if I had learned the grid before I went to the computers it would have been better….Then the computers may have been more helpful But, it was good practice (the computers were)".

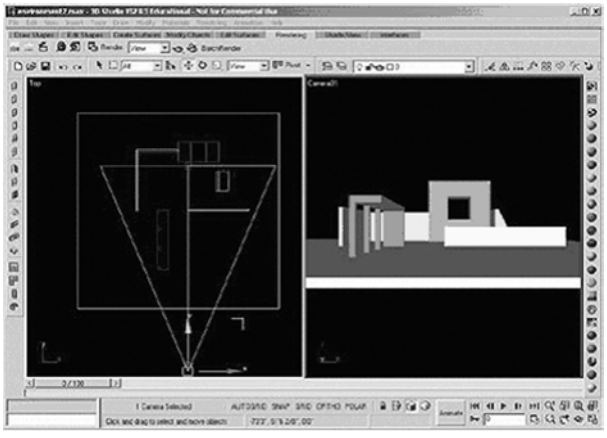

Figure 5. Perspective of the 3-dimensional configuration used for the test.

"I believe I got a better understanding of space and perspective by the hand drawn method, and I believe if one is to use the computer, you should first learn the hand drawn method. This way one can better appreciate and use the computer".

"It was easier using the grid than the computer program. There was something about actually putting pencil on paper that the computer cannot produce".

"With the grid my "guesses" were much closer because I had a better understanding of how the heights related to each other…On both styles, my distance was too long".

"The computer exercise would have been less frustrating with a basic understanding of how proportions work with the Horizon line….Both exercises were helpful and did improve my skills".

"This whole experiment was pretty difficult for me….My main problem is that I always tend to visualize what I see as an aerial view, so drawing at specific eye levels was difficult….The computer didn't really teach me anything to improve with, but seeing the correct view did tell me how I was wrong….The grid helped me to understand how things are situated….I had troubles with the grid, but did better than without it".

3.5 Results

A curious pattern developed when we began the evaluation of the exercise. Although the students seemed almost without exception to believe that they were more prepared to make perspective views after the "traditional" one point grid session, the results of the testing showed the opposite. It appears that while the "digital" group did not conceptually understand the workings of the grid as thoroughly as the "traditional" group, they had nevertheless cultivated a sense of what any given view should look like. Stated differently, by the repeated iterations afforded by the more visually agile computers, the students were developing an intuitive sense of how any given view should appear. Meanwhile the students who literally constructed each view tended to treat each view as an analytical problem, heeding less their intuition regarding appearance.

The following chart (figure 6) illustrates the level of accuracy achieved by each group of students:

In total, the group trained with the Traditional Method produced 7 accurate perspectives at the same time that the group trained with the Third-Eye Method achieved 14 accurate perspectives. At the other end of the spectrum, the group trained with the Traditional Method produced 36 inaccurate perspectives at the same time that the group trained with the Third-Eye Method produced only 17 inaccurate perspectives. Both groups produced about the same number of average perspectives.

Views	View 1		View 2		View 3		View 4		View 5		View 6	
Method	Traditional	Third Eye	Traditional	Third Eye	Traditional	Third Eye	Traditional	Third Eye	Traditional	Third Eye	Traditional	Third Eye
Level of Accuracy												
Accurate	0	3	1	1	3	3	0	2	1	2	2	3
Average	6	3	4	2	2	3	3	2	2	5	1	2
Inaccurate	3	2	4	5	4	2	6	4	6	1	3	3

Figure 6. Level of accuracy achieved by each group of students in each view.

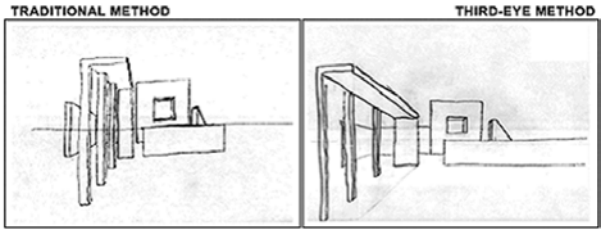

Figure 7. Examples of students' tests.

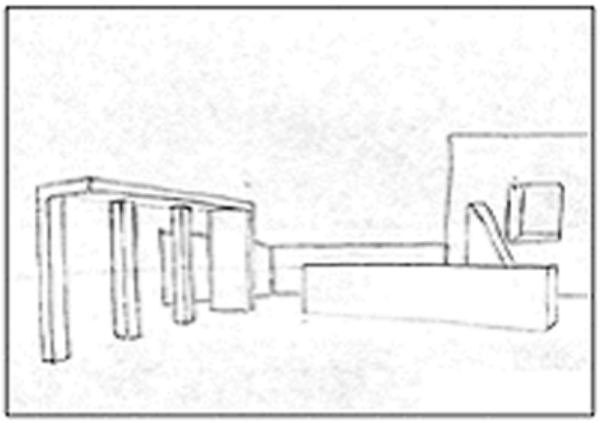

Figure 8. The student trained with "The Third Eye Method" explored the production of two-points perspectives on an intuitive way when asked to produce a perspective from an unsolicited viewpoint.

It is evident that the group trained by means of the Third-Eye method was able to produce more accurate views and less radically distorted views. It was in particular interesting to see that a considerable number of students trained by means of the traditional method had clear difficulties controlling the magnitude of depth in their perspectives. (Figure 7)

As a pattern, students trained with the "Traditional Method" had problems representing an accurate distance between elements (in the x axis), and exaggerated the depth of the perspective (in the y axis). The students trained with "The Third-Eye Method" managed a higher level of accuracy.

Additionally, the analysis of the last drawing produced in the testing session shows that the students trained by means of the Third-Eye Method were able to establish more attractive viewpoints than the students trained by the traditional method (Figure 8)

4 Conclusions

From our observations during training sessions and the analysis of test results we can arrive to the following conclusions:

- The level of student comfort was substantially higher in the traditional training setup. The students were able to understand the process through which they were going to achieve accuracy in the interpretation of views. That gave them considerable confidence and made the learning experience more enjoyable. On the other hand, their skills on the production of fast free hand perspective drawings were not substantially enhanced. Their ability to draw remained analytical and therefore constrained by the amount of time and level of focus that was invested.
- The students trained by means of the Third-Eye Method had difficulties understanding how they were enhancing their free hand perspective drawing skills. Most students struggled with the initial views feeling frustration and embarrassment. Improvements in their accuracy resulted on a more positive attitude but they were yet uncomfortable with their apparent lack of control. Their training session became enjoyable at the end when of-

fered the opportunity to add to the environment and select the most attractive viewpoint they could imagine. That last activity of the session was design oriented and generated positive excitement.

- At the time of testing, the students trained by means of the Third-Eye Method were able to avoid heavily distorted views, achieved higher level of accuracy and identified more attractive points of view than the students trained by means of the traditional method. These three observations make evident that the first group gained cognitive visualization skills that the second group did not. It is also evident that the first group gained considerable ability on handling the transfer of mental imagery to a drawing as an exercise in synthesis.
- The results of 3 hours of training by means of the Third-Eye Method have been far more evident than expected.

5 Future Implementations

Based on our understanding of why our students are showing limitations on their ability to draw, and the results of applying the Third-Eye Method as a means for improvement, we need to conclude by pointing out that it is certainly worth further use and experimentation.

We find that our students need to be trained in both analytical and synthetical methods. The first one will offer them understanding of the principles that rule perspective drawing at the same time that the second one will allow them to effectively draw fast free hand perspectives in direct relation to their cognitive visualization capabilities. In future implementations, the students will be initially exposed to the analytical method followed by the Third-Eye Method. It is our understanding that this will raise de level of comfort that the students need for handling the more challenging but rewarding experience offered by the Third-Eye method.

We believe that "The Third-Eye Method" is addressing a training issue for which we have lacked in terms of training tools. One of the most difficult things an architect does is to imagine something beyond reality and capture that imagery as a synthesis. The Third-Eye Method can help us achieve the level of skillfulness that permits us to grab a piece of paper and sketch what only exists in our imagination

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