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# WHY A SEEING SPACE?

## SOFTWARE-BASED TOOLS ARE TRAPPED IN TINY RECTANGLES.

FOR YEARS, I'VE BEEN DESIGNING TOOLS. TOOLS FOR PEOPLE MAKING SOFTWARE... ELECTRONICS, MUSIC, ANIMATION, MATHEMATICAL SYSTEMS... THINGS WITH COMPLEX BEHAVIOR.

MY FOCUS HAS ALWAYS BEEN—HOW CAN DESIGNERS SEE THAT BEHAVIOR? HOW CAN THEY SEE WHAT THE THING THEY'RE BUILDING IS ACTUALLY DOING? AND WHAT ARE POWERFUL WAYS OF SEEING SO THEY CAN UNDERSTAND WHAT IT'S DOING?

THESE HAVE GENERALLY BEEN SOFTWARE-BASED TOOLS. WHAT "SOFTWARE-BASED" MEANS TODAY IS THAT THESE TOOLS ARE TRAPPED INSIDE A TINY RECTANGLE THAT FITS ON YOUR DESK.

TO DO YOUR WORK, YOU SIT AT YOUR DESK AND YOU STARE AT THIS TINY RECTANGLE. AND THIS FRUSTRATES ME.

## REAL-WORLD TOOLS ARE IN ROOMS, WHERE WORKERS THINK WITH THEIR BODIES.

IF YOU THINK ABOUT MANY TRADITIONAL FORMS OF CRAFTSMANSHIP, THEY TAKE PLACE IN A SOCIAL ENVIRONMENT—A ROOM—DESIGNED FOR THAT PURPOSE.

WHERE THE WORKER IS SURROUNDED BY TOOLS. WHERE THEY WALK AROUND. USE THEIR BODY. USE THEIR HANDS.

WHERE THEY THINK ORALLY. THE ROOM BECOMES A MACHO-TOOL THEY'VE EMERGED INSIDE. AN EXTENSION OF THE BODY.

SO, I'VE BEEN TAKEN WITH THE IDEA OF DESIGNING TOOLS IN THE FORM OF ROOMS. THIS LED TO THINKING ABOUT MAKER SPACES. MAKER SPACES ARE COMMON WORKSPACES WHERE PEOPLE COME TOGETHER TO CREATE IN A SHARED SOCIAL ENVIRONMENT.

WITH ACCESS TO HIGH-END EQUIPMENT THAT WOULD BE TOO EXPENSIVE FOR INDIVIDUALS. LIKE THESE TWO ASPECTS OF MAKER SPACES... AND I LIKE THE PHILOSOPHICAL MOVEMENTS BEHIND THE "MAKER MOVEMENT"—INSTEAD OF CONSUMING MASS-PRODUCED PRODUCTS, PEOPLE SHOULD MAKE THEIR OWN THINGS.

THIS TALK IS ABOUT A WAY TO TAKE THESE MAKER GOALS TO THE NEXT LEVEL. BY DESIGNING A NEW KIND OF SPACE THAT CHALLENGES AND IMPROVES CREATORS IN WAYS THAT TODAY'S WORKSPACES DON'T SUPPORT.

## TODAY'S MAKER SPACES PROVIDE TOOLS FOR BUILDING.

IF YOU WALK INTO A MAKER SPACE TODAY, YOU'LL PROBABLY SEE—

A LASER CUTTER. A 3D PRINTER. WELDING EQUIPMENT, PLASTIC-FORMING EQUIPMENT.

LATHES, MILLS, DRILLS. SAWING, SANDING, BENDING.

THESE ARE WONDERFUL TOOLS, BUT THESE ARE ALL CONSTRUCTION TOOLS. THESE ARE TOOLS FOR BRINGING MATERIALS TOGETHER. THESE ARE JUST THE TOOLS YOU NEED IF YOU WANT TO MAKE SOMETHING.

OR SIMPLE MECHANICAL CONTRACTIONS. BUT MORE AND MORE, THE PROJECTS THAT PEOPLE WANT TO MAKE ARE OF A DIFFERENT KIND...

## MODERN PROJECTS HAVE COMPLEX BEHAVIOR.

TODAY, PEOPLE ARE MAKING THINGS LIKE— AND ROBOTS THAT FLY AROUND. ROBOTS YOU CAN TALK TO. ROBOTS THAT TEND YOUR GARDEN.

CLOTHING THAT LIGHTS UP. AND RESPONDS TO HOW YOU MOVE. OR RESPONDS TO PEOPLE AROUND YOU. MEDICAL INSTRUMENTS.

DRIVE DISPLAYS. BOOK SCANNERS. 3D PRINTERS. SELF-BALANCING VEHICLES.

THESE KINDS OF PROJECTS HAVE HIGH INTERNAL COMPLEXITY (OFTEN WITH EMERGED SOFTWARE). GIVING RISE TO COMPLEX BEHAVIOR. THEY'RE OFTEN TAKING INPUT FROM THE OUTSIDE WORLD. AND RESPONDING TO THE WORLD IN COMPLEX WAYS.

## THE CHALLENGE IS NOT BUILDING THESE PROJECTS, BUT UNDERSTANDING THEM.

WITH THESE PROJECTS, THE PRIMARY CHALLENGE IS NOT PUTTING THE PIECES TOGETHER. THE PRIMARY CHALLENGE IS UNDERSTANDING WHAT THE THING IS DOING. AND WHY IT'S DOING THAT. AND HOW WE CAN GET IT TO DO WHAT WE ACTUALLY WANT IT TO DO.

FOR EXAMPLE, SAY WE'RE MAKING THIS LITTLE ROBOT WHICH IS SUPPOSED TO MOVE TOWARDS THE LIGHT. WE TURN ON THE LIGHT... AND... IT DOES NOT MOVE TOWARD THE LIGHT. WHAT DO WE DO?

WE HAVE TO GET IN THERE! WE HAVE TO GET INSIDE THAT ROBOT'S HEAD, AND SEE WHAT IT'S THINKING, AND COME TO UNDERSTAND WHAT'S BEHIND THE WAY IT'S BEHAVING.

THE CONSTRUCTION IDEAS WON'T HELP US HERE. WHAT WE NEED ARE SEEING TOOLS. WE DON'T HAVE MANY OF THOSE, AND THE FEW WE HAVE ARE VERY FRAGILE. THEY'RE REMAINERS THAT SIT ON A DESK.

## UNDERSTANDING REQUIRES SEEING, AND THE BEST SEEING TOOLS ARE ROOMS.

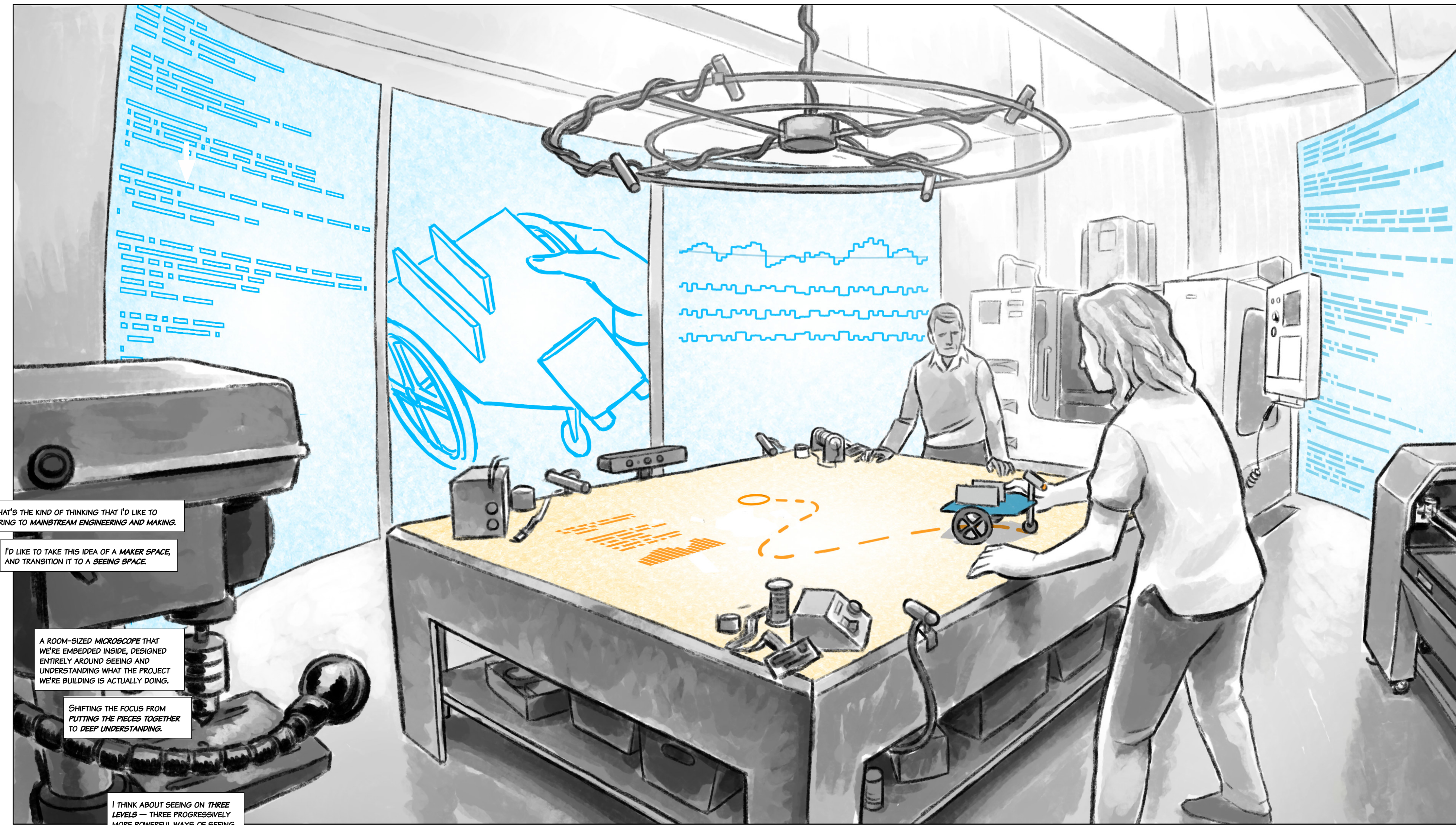
ON THE OTHER HAND, THERE ARE SOME PEOPLE THAT TAKE SEEING VERY SERIOUSLY. FOR EXAMPLE, HERE'S HOW NASA DOES IT. IF YOU'RE LAUNCHING A SPACE SHUTTLE, YOU NEED TO UNDERSTAND EVERYTHING THAT'S GOING ON IN THIS VERY COMPLEX SYSTEM.

THIS IS THE CALIFORNIA POWER GRID. A CANADIAN POWER GRID.

A WASTE TREATMENT FACILITY. A TV STATION. THE LARGE HADRON COLLIDER AT CERN, WHERE THEY RECENTLY FOUND THE HIGGS BOSON.

THESE PEOPLE KNOW THAT IF THEY'RE TRYING TO DESIGN A SYSTEM OF THIS COMPLEXITY, A SYSTEM THAT WE HAVE TO UNDERSTAND IN REALTIME, WE NEED A ROOM—WHERE WE CAN BE IMMERSIVE IN SEEING TOOLS.

# WHAT IS A SEEING SPACE?



## 1 SEEING INSIDE

FIRST, BEFORE WE CAN SEE ANYTHING, WE SEE SOMETHING TO SEE. WE NEED A WAY OF COLLECTING DATA, AND A WAY OF DISPLAYING THAT DATA.

SAY WE'RE MAKING THIS LITTLE ROBOT. JUST THE BASIC MINIMUM OF SENSORS. THE BASIC MINIMUM PROCESSING POWER. THE BASIC MINIMUM COMMUNICATIONS CAPABILITY.

AS A RESULT, MOST OF THE INFORMATION WE'D ACTUALLY WANT TO SEE IS NEVER COLLECTED OR ACCESSIBLE IN THE FIRST PLACE.

I'VE BEEN SO MANY PROJECTS FAIL AT SOME POINT BECAUSE SOME WIRE CAME LOOSE. THE CONVENTIONAL THINKING IS THAT IT'S THE FAULT OF THE BUILDER OR NOT ATTACHING THE WIRE STRONGLY ENOUGH. THE WAY I SEE IT, IT'S THE FAULT OF THE WIRE FOR BEING TOO DAMN TO KNOW WHETHER IT'S ATTACHED.

COLLECTING DATA. WE NOW LIVE IN A WORLD WHERE SENSORS ARE CHEAP. PROCESSING IS CHEAP. AND TRANSMIT THAT DATA UP TO THE ROOM.

WE NEED TO START WORKING WITH CHEAPER MATERIALS. THAT COLLECT A LOT OF DATA ABOUT THE INTERNAL STATE. AND COLLECT DATA ABOUT THE EXTERNAL ENVIRONMENT.

DISPLAYING DATA. AND THEN THE ROOM IS DESIGNED TO REFLECT ALL THAT INFORMATION BACK TO US—SO ANYTHING WE'D WANT TO KNOW IS JUST A GLANCE AWAY.

TO BE EFFECTIVE, ALL OF THIS MUST GET DAMN FAR AWAY! DATA COLLECTION IS ROUTED BY TO THE MATERIAL, DISPLAY IS ROUTED IN TO THE ROOM. NO ADDITIONAL EFFORT REQUIRED. WE JUST SHOW UP AND START WORKING, AND ALL THESE TOOLS ARE ALREADY AT OUR DISPOSAL.

## 2 SEEING ACROSS TIME

NOW, WE CAN THINK ABOUT HOW TO DISPLAY THE DATA. WHAT ARE POWERFUL WAYS OF REPRESENTING THIS INFORMATION? ONE OF THE MOST POWERFUL WAYS IS TO SHOW TIME.

WE TEND TO SEE THINGS MOMENT-TO-MOMENT, THINK MOMENT-TO-MOMENT. IT'S NOT UNTIL WE STEP BACK FROM THOSE MOMENTS AND LOOK ACROSS A RANGE OF TIME AT ONCE... THAT WE CAN START TO NOTICE PATTERNS, AND THINK ABOUT SYSTEMIC CAUSES.

SAY WE TURN ON OUR ROBOT. AND IT DOES SOMETHING INTERESTING HERE. THE MOMENT GOES FAST. BUT WE WANT TO GRAB IT AND RUN IT BACK.

CONTROLLING TIME. WHY NOT? WHY NOT WORK IN A SPACE WITH VIDEO CAMERAS EVERYWHERE, EVERYTHING IS RECORDED, EVERYTHING IS MARKED AND TRACKED.

JUST LOOK UP, GRAB TIME. RUN IT BACK, SEE WHAT HAPPENED. PUT CONTROL OF TIME INTO THE MAKER'S HANDS.

SEEING ACROSS TIME. AND LOOK ACROSS A RANGE OF TIME AT ONCE. SEE THE PATH THE ROBOT TOOK. SEE ALL THE DATA COLLECTED DURING THE RUN. SEE WHAT THE SENSORS SAW, SEE THE INTERNAL VARIABLES. COMPARE WHAT HAPPENED THIS TIME TO WHAT HAPPENED LAST TIME. UNDERSTAND THE EFFECTS OF CHANGES.

AUTOMATIC NOTEBOOK. ALL OF THIS DATA CAN BE STORED FOREVER, BECAUSE DIGITAL STORAGE TODAY IS FREE. SO THE ENTIRE HISTORY OF THE PROJECT CAN AUTOMATICALLY BECOME A NOTEBOOK.

BROWSE THE PROJECT'S HISTORY. SEE ALL THE VIDEO, ALL THE DATA, ALL THE NOTES THAT WE TOOK. AND SEARCH THE PROJECT'S HISTORY. IF A SENSOR BEHAVING STRANGE HIGH... EXAMINE SESSIONS IN THE PAST WHERE THAT SENSOR BEHAVING STRANGE ALSO HIGH.

# WHY IS SEEING SO IMPORTANT?

THE WAY I SEE IT, "MAKING" EXISTS ON A SPECTRUM. THERE ARE THESE DIFFERENT WAYS OF THINKING THAT WE DRAW ON, IN DIFFERENT COMBINATIONS, AT DIFFERENT TIMES—

**TINKERING** TINKERING IS WHERE WE'RE TRYING THINGS OUT, TRYING TO FIGURE SOMETHING THAT SEEMS TO WORK.

**ENGINEERING** ENGINEERING IS WHERE WE GO UNDERSTANDING OUR DESIGN PRINCIPLES—VERY POWERFUL, BUT THIS THEORY OFTEN COMES FROM SOMETHING LIKE A TESTBOOK. HOW DO WE WORK IN A DOMAIN WHERE THE TESTBOOKS HAVEN'T BEEN WRITTEN YET?

**SCIENCE** IN THE SCIENTIFIC WAY OF THINKING, WE'RE DISCOVERING AND ARTICULATING THOSE UNDERLYING PRINCIPLES. WE'RE GENERATING THAT THEORY THAT ENGINEERS RELY ON—BUILDING THOSE MODELS.

HERE'S WHERE THIS ALL FITS IN WITH TOOLS.

**TINKERING** WITH BUILDING TOOLS AND CONCEPTUAL TOOLS AND SEEING TOOLS. BUT TO SPAN THIS ENTIRE SPACE—TO DRAW ON ALL THESE WAYS OF THINKING AT ONCE—THEY NEED TOOLS TO SEE WHAT'S REALLY HAPPENING AND MAKE SENSE OF IT.

IF YOU JUST GIVE SOMEONE "MAKING" TOOLS, AND TEACH THEM HOW TO USE THEM, THEY CAN WORK IN THIS RANGE. AND IF YOU THEN GIVE THEM THEORY, HOW THEY THINK ABOUT THINGS, AND IF YOU THEN GIVE THEM THEORY, HOW THEY THINK ABOUT THINGS, AND IF YOU THEN GIVE THEM THEORY, HOW THEY THINK ABOUT THINGS...

## 3 SEEING ACROSS POSSIBILITIES

THERE'S AN EVEN MORE POWERFUL WAY OF SEEING, WHICH IS SEEING ACROSS DIFFERENT DESIGN ALTERNATIVES. DO WE MAKE THE ROBOT BEHAVE LIKE THIS OR LIKE THAT? WE SEE IT BOTH WAYS AND COMPARE THEM.

IT MIGHT NEED A BETTING, TO SAY HOW GENERATIVE IT SHOULD BE TO THE LIGHT. THAT'S OFTEN DONE TODAY WITH A "KNOB". WE TRY IT ON THIS SETTING... IF THAT DOESN'T WORK YOU WELL, WE TRY IT ON THIS SETTING... IT'S VERY AD HOC, VERY UNSYSTEMATIC. WHY NOT WORK IN AN ENVIRONMENT WHERE, INSTEAD OF CHOOSING ONE PARTICULAR SETTING... WE SEE ACROSS AN ENTIRE RANGE AT ONCE.

AUTOMATIC EXPERIMENTATION. WE SAY "GO", AND THE ROOM AND THE MATERIALS KNOW TOGETHER TO DO A TEST RUN AT THAT SETTING. COLLECT THE DATA... THEN AUTOMATICALLY TRY THE NEXT ONE, AND THE NEXT ONE... GO THROUGH THE ENTIRE RANGE, TRY THEM ALL OUT, COLLECT ALL THE DATA.

THEN WE JUST LOOK AND SEE WHAT ACTUALLY HAPPENED IN ALL THOSE CASES. WE CAN TAKE MEASUREMENTS, REMOVE THE DATA, FIGURE OUT WHICH IS THE BEST ALTERNATIVE. AND NOT JUST WHICH IS THE BEST, BUT WHY IT'S THE BEST. WE CAN SEE ALL THE CONTRAST.

LET'S DESIGN A SPACE WHERE THE ENTIRE FOCUS IS ON UNDERSTANDING WHAT THE COMPLEX THINGS WE'RE BUILDING ARE ACTUALLY DOING. LET'S SHIFT THE EMPHASIS AWAY FROM PUTTING PARTS TOGETHER, AND TOWARDS SEEING IN MANY POWERFUL WAYS.

SOME OF THESE WAYS MAY BE ENGINEERING CHALLENGERS, AND WE AS A CULTURE HAVE DECIDED THAT THESE ARE PUNISHABLE THINGS THAT ARE WORTH OUR EFFORT. AND THERE MAY BE SOME ENGINEERING CHALLENGERS INVOLVED... BUT 3D PRINTERS AND SPACE SHUTTLES ARE ALSO ENGINEERING CHALLENGERS, AND WE AS A CULTURE HAVE DECIDED THAT THESE ARE PUNISHABLE THINGS THAT ARE WORTH OUR EFFORT.

THE MAIN THING THAT'S NEEDED IS SIMPLY THE RECOGNITION OF HOW IMPORTANT SEEING IS, AND THE WILL TO DO SOMETHING ABOUT IT.