

The realization of engineering students' agency in laboratory driftworks

(draft, please do not cite; comments are welcome)

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Abstract

Drawing from the insights into agency in STS, I propose a 'driftworks of deployment' perspective to theorize about the constitution of engineering trainees' agency. It is suggested that the trainees' agency is enacted in the trajectories of dispersive deployments, the driftworks.

In this paper, starting from the dual visions on these training deployments, my fieldwork unveils the entanglement of multiple aspects of students' agency and its fluctuations and I then investigate the experiences with the driftworks perspective. In the end, this paper locates the realization of the multiple aspects of agency in the training driftworks and also suggests its practical implications for current engineering training in Taiwan.

Locating agency

'Agency' is one of the hotly debated and constantly re-conceptualized terms in STS. These re-conceptualizations usually start from a common ground acknowledging that human is not the only maker of our world. With various problematics in mind, while emphasizing the dynamical process of the interplay between ideas, things, and people, Andrew Pickering(1995) and Actor-Network theorists(Law 1987; Latour 1988; Callon 1999) highlight the mangle and the intertranslatability of heterogeneous agencies. While tackling the situational constitution of technoscientific facts and artifacts, Thomas Hughes(1983) and Joseph Rouse(1987) propose an ecological approach to delineate the configuration where the agency of scientific facts and artifacts is constituted. While taking the implicit aspect of technoscientific practices into consideration, Harold Collins(1982; 1982) and Ethnomethodologists (Garfinkel 1986; Suchman 1991; Lynch 1993) address the tacit, material, and spatial embodiment of

human agency.

These dynamical, ecological, and embodiment approaches point to a new direction of conceptualizing agency. It starts from recognizing that various non-humans not only enable human to act in particular ways but also co-constitute what was identified as ‘human agency.’ Thus, agency, firstly, is not an inherent characteristic of human and it is not necessarily located within the intending human mind or body. Furthermore, agency is dispersed in the situated configurations of things, ideas, institutions, and human bodies. The agency in such a configuration perspective is not a static property; it can be articulated, obstructed, re-distributed, and diverted in practices. Based on the insights from ANT and Pickering about the interchangeability, from Hughes and Rouse about the disciplinary micro-worlds configuration, and from Collins and ethnomethodologists about the embodied extension and sediment, here, I propose to think about agency as the momentum that is produced in particular technoscientific configurations. That is, agency is the potency intrigued by the deployment of technoscientific practices. The particular potency in a specific deployment is what I call a ‘deployment of agency.’

This concept of ‘deployment of agency’ is not only about human agency; despite that human is an important part of the deployments and the discussion of this paper is focused on human. Looking closely into the trajectory of a technoscience, there are various deployments, and what used to be understood as ‘human agency’ is like the tip of an iceberg. ‘Human agency’ is actually an epitome of a whole set of deployments that has been ‘condensed’ in the forms of the person’s institutional role, working relationships, memorized knowledge, practical skills, subconscious awareness, or even the works artifacts have done in the name of the person.

For example, when an engineering team made a circuit, we can attribute the achievement to the humans. Think in terms of deployments. First of all, we can say that the circuit is a materialized deployment where electrons are manipulated and specific signals are produced to initiate further action of machines (such as intriguing an alarm) or humans (such as reading the signals and modifying the circuit). Furthermore, those humans were also ‘deployed’ so as to be able to design and make the chip; various tutorial classes, textbooks and examples, software, and curriculum on circuitry of their engineering training are some deployments involved. Moreover, the chip might go through further deployments, such as being applied in some products and promoted with specific discourse and images, and then itself might become a deployment of the users’ agency. For example, mobile phones becomes an

indispensable part of our nowadays communicability. Of course, It is not surprising that there might be alternative or counter deployments take place in the process and turn the technoscientific process into contingent trajectories of dispersive deployments. Thus, from this perspective, technoscientific practices are composed of deployments of various kinds and scales; a deployment can be as small as the manipulation of a microchip or a gene, and as big as an international consortium for industry standard; as ‘upstream’ as the conception of an idea, and as ‘downstream’ as the industrially manufactured products. Among the multitude of contingent deployments, what was so called ‘human agency’ appears both as deploying practices and as deployed effects in many ways. In sum, agency is realized in the dispersive trajectories of momentum of various deployments.

Furthermore, in order to think about the relationships between deployments and the ongoing, dispersive trajectories of agency, I propose a ‘driftworks’ approach. This term was originally mobilized by J. F. Lyotard to challenge the images of well structured psychal being in psychoanalysis and social being in sociology. Lyotard argues that, instead of being structured by a monotheistic and homogeneous power, we are under the influences of driftworks of political, ideological, economical, cultural, and educational influences, etc. and these forces of different orientations contribute to the making of a not so well structured psyche and society. This driftworks approach is adopted for empirical and theoretical reasons.¹ Empirically, on the one hand, thinking about technoscientific practices as driftworks provides a more realistic idea of the ongoing dispersion of technoscientific trajectories. On the other, as the abundant literature in STS showing that technoscientific practices always involve multiple actors in various situations (Mackenzie and Wajcman 1985; Shapin and Scaffer 1985; Latour 1987; Pinch and Bijker 1987; Law and Bijker 1992; Fujimura 1996; Mol and Berg 1998; Oudshoorn and Pinch 2003), my fieldwork and interviews indicate that engineering practices are not limited within the physically, organizationally, and technologically defined laboratory. Instead of thinking about to what extend, whatever organizationally, socially, technologically, or intellectually, should the term ‘laboratory’ been extended, I use this new term ‘driftworks’ to emphasize the multi-sited technoscientific practices and their dispersions.

¹ This driftworks perspective has been proved useful in my previous study of the agency of patients living with a medical technology, hemodialysis(Lin 2005). By using the term driftworks, I emphasize both the ‘drift’ and the ‘work’ in order to illustrate how these patients’ trajectories of living within the medico-socio-technological configuration of dialysis are ‘determined’ as well as ‘enacted’; dialysis patients’ existence is mediated in the practical embodiment of self-care, in the bedside treatment of dialysis apparatus, in the discussion of policy meeting, in the dynamics of social protests and news events, and in the expressions of their everyday situations, etc.

In my observation, technoscientific practices are the momentums moving around the various deployments of multiple sites; while many efforts have been devoted into directing the technoscience moving according to our wish, but these practices are sometimes drifting along with the agencies in the form of black-boxed machines, technical standards, institutional rules, or other people's actions, etc., that are resisting to our own. In this sense, theoretically, this driftworks approach also emphasizes not only the ongoing aspect of technoscientific trajectory, but also the tension between the intended and the determined, between the active and the passive moves of technoscience.

From invention to training driftworks

In order to understand the constitution of agency from such a driftworks perspective, different from most of the cases in STS, I examine the training of students. First of all, this has to do with the imbalanced discussion about agency. Apart from Collins' (1982; 1982) study of TEA laser replication, most of the studies in STS are about the cases of, paraphrasing Latour (1987), 'already agency' of those practising scientists and engineers. In contrast to that, I want to contribute to the less explored situations when these practitioners are under training, and see what happen to their agency.

Furthermore, despite that previous studies of agency have converged on the post-humanist thesis that de-centering human by bring in the dynamical and material configuration of human agency, a human's experiences of his/her agency or lost agency are relatively less explored. Following the symmetrical way of thinking, I think that the post-humanist turn has fully made its point on the non-humans, and it is time to probing further into the experiences of the humans with these non-humans in mind in order to think about their agency (Leigh-Star 1991; Martin 1992; Franklin 1997; Cussins 1998; Mort 2002; Akrich and Pasveer 2004). In this sense, I want to examine the 'training driftworks'² of engineering in order to understand the

² What I am referring to as 'training driftworks' are those practices in the various situations that make up the technoscientific deployments of trainees' agency. Driftworks is useful to think about the laboratory training. While engineering students in these laboratories can explain quite specifically what their experiments are about, their answers to our questions regarding to the boundary of the laboratory are surprisingly vague. In terms of the spatial boundary, they says that a laboratory is where they do their research and since they are almost doing research all the time, except in their sleeps, so the laboratory is almost everywhere. In terms of the temporal boundary, most of their weekly schedules are based on the progress of their research and the deadlines of the progress reports, and their daily schedules are basically a further refinement of the weekly schedule. So they daily life is scheduled by the project they are doing. In terms of the organizational boundary, many of them, apart from those have a partner and have to spend time together, say that the laboratory members work and play together. Apart from those having partners and are more aware of and have to spare some time for their partners, Ph.D. students are more aware of such an 'unhealthy lifestyle' and are more actively segregating their work time and leisure time as long as they are in control of the progress, but because of master

constitution of human agency.

Fieldwork and Data

The materials discussed in this paper are collected from my fieldwork of four engineering laboratories. This fieldwork is part of my involvement with a three year long interdisciplinary project. The project has been running for one year. The research team is made of four engineering, one law and one sociology subproject leaders and their students. The four engineering laboratories are in areas of bio-electronic engineering, wireless communication, chemical engineering, and bioinformatics.

I and my research team are following the process of technological construction and the laboratory members' experiences. The materials presented here are about the process of technological construction of the first year. We conducted recorded semi-structured interviews and on site ethnography. We observed, photographed and filmed their private discussions, meetings, experiments, and other activities. We also collected research notebooks, sketches, presentation power points and other files from those students and all of their research files and their thesis when they have finished their degree.

The institutional training deployments

In the following, in order to be more focused, I discuss the institutional training arrangements, the material and real time practices are not discussed in this paper.

The engineering students I am referring to here are mainly students doing their master degrees and some of them are Ph.D. students. In the engineering departments in Taiwan, a master degree usually takes two years to finish, and in order to do so, students have to be pushed to their limits; sometimes they enter the laboratory in the first application as early as ten month before the official day of enrollment of new students. From then on, they have to read and present literature in meetings to get familiar with the project they are going to do, take courses, and undergo instrument trainings and pass license examinations. The initial warming up takes a few months, but varies according to differences in discipline, the techniques and instruments needed, and the size and the current situation of the project. After that, they spend almost the rest of the first year in surveying and studying the literature, and copying

students' positions and lack of experience in arranging their daily lives, they are usually living a laboratory-centered or laboratory-only live. In other words, most of the students spend all of their time and social life within the laboratory in the two years time, and everything they do is more or less related to their laboratory members and their works.

techniques so far achieved, and try to develop the ideas about their own thesis. After that, in the second year they become the seniors in the laboratory, and they have to begin to specify the research method, construct the working apparatus or model, finalize the standard operation procedure for their research, or produce the data in first two third of the second year. During the process, they are asked to report their progress on a regular basis. Their thesis is usually compiled from the reports and data produced in the process in the last few months. It is very important that in their second year these senior students have to train the juniors going to continue their projects at then same time, and pass on their files, data, techniques, everything related to the project to the juniors after they have finished.

In order to finish the degree within two years, these students have to devote all of their time and energy and there are many institutional arrangements helping them to achieve the aim. These institutional arrangements that shape the trajectory and organization of a student's career, and hence their agency; they are the temporal deployments of succession and progress report, and organizational deployments of hierarchical division of labor. After that, I will describe the duals visions on students' agency. In order to transcend the dual visions, I use the driftworks perspective to propose a new dynamical understanding of the multi aspects of agency in realization.

Succession

It is quite common that engineering students begin their study by learning from the seniors. This is called 'succession' (*Chuan chen*, 傳承) and is arranged at the institutional and practical aspects. Here I focus on the institution. When it comes to the constitution of the technoscientific agency of these students, it is quite reasonable that since each engineering discipline is highly specified and each laboratory has its own research interest and strength, rather than asking student to start from the basics, the succession enables students to learn the state of the art techniques and knowledge and helps the laboratory keep going. In this sense, this succession deployment is enabling the students to align with technical agency and become part of the community.

According to these students, as long as a project goes on, the old and new members of a project are like in an endless relay race; senior members pass their experiences and techniques to the succeeding junior students. Each generation of them participates in a particular period of the succession, and the techniques and expertise will finally accumulated in the laboratory in the form of the succeeding members' embodied 'know hows,' published papers and patents, artifacts, and the research networks, etc. 'It is only in this way,' a student says, 'the laboratory will get stronger and stronger.'

Such an arrangement for the endless succession is the most important deployments of the students', and a laboratory's, agency; since it is in dispersive unfolding, we can also think about succession in terms of the driftworks of technical agency.

Within this succession deployment, when a new student starts her/his study, s/he will soon find out that s/he is expected to master a very specific research or experiment in order to finish her/his thesis. Sometimes when the student happens to be the first generation of a new project, s/he will have a higher degree of freedom, but it also means that s/he will make much more efforts since s/he has to learn the fundamental literature, equipments and techniques, build up the standard operation procedure (SOP), try the best variables for the basic manufacture, measurement and system integrations from scratches. When a laboratory has been running for a few years, the pattern of the dispersion of research topics is usually like a family tree, and by then most students are somehow in at least one of the threads of the succession. We can say even that the most substantial existence of a laboratory is not represented in its physical existence or in its leader, but in the existence of the nexus of succession deployments and the related driftworks.

Progress report and meeting

In this sense, within the succession deployment, students rarely say that they *choose* a research topic; they usually say that they *are assigned to* do the topic by the Ph.D. students or their supervisor, the leader of a laboratory. This is quite understandable from the concept of driftworks of deployments; since a student is only part of the driftworks, the coupling of a research topic and a researcher is more like the student align her/himself with the momentum of the project/laboratory, and in order to do so the student has to put oneself in the various deployments of embodiment (learning techniques), knowledge, institutional relationships, etc.. The person assigning the topic is just an epitome of all these. When the research topic is assigned in this way, further deployments, progress report and meeting, follows in order to help the students to learn the achievements and move on to their part as soon as possible.

Most of the time, progress reports take place in the meetings. This deployment is widely used in all levels of an engineering project. In the case of an interdisciplinary project we join in, a progress report happens in at least the occasion of three different levels; in the regular joint meeting of the teams of subproject leader and their students, in the group meeting within a laboratory between the leader and students, and in the pre-meeting between a Ph.D student and the student in his/her group before the joint meeting or group meeting. Such deployments are regard as necessary both by the

leaders and the students. Despite that in these occasions, for the leaders, these occasions are about helping students with the difficulties, supervise their progress, and guide the direction of further research, and for the students are more about progress checking than learning.

In this sense, it is no wonder that students are not thinking about how to learn more in the presentation of these meetings, but how to have the presentation done with less trouble. Therefore, some further deployments develop. Our fieldwork includes all three levels of meetings, and we also talked to the students and the leaders before and after the meetings. It is quite interesting to see that some informal deployments are developed among students in response to this well institutionalized progress report deployment. For example, the pre-meeting between Ph.D. and master students is not only a discussion of data, research design and methods, and ideas, those issues to be presented, but also a tutorial course on how to present the beautiful side of the data, how to guide the audience to ask the answerable questions, and what kind of reply can stop the leader asking more questions, etc.

Hierarchical division of labor

Succession and progress report are the deployments that shape the trajectory of the temporal constitution of students' agency, the hierarchical division of labor is a deployment on the organizational aspect.

In fact, division of labor is closely related to progress report in term of doing a project and having meetings. When doing a project, we can see that the master students are doing the experiments and produce the data, the Ph.D students are helping the master students to do these works, controlling the progress, and writing the draft papers, and the laboratory leaders usually give guidelines and ask the students about the progress. This is represented in meetings; master students present the data and the difficulties they have in experiments. Ph.D. students report the progress of a project, their evaluation of instruments, and other information regarding to conferences, writing and submitting draft papers and proposals. The leaders give orders and ask for more production, talk about the theoretical and industrial implications of their works, and sometimes discuss the possibility of applying for further grants between themselves.

Because of this hierarchical division of labor, sometimes students feel that they are not doing a *research* for their study but merely doing *work* for the laboratory leader's project. This feeling is reflected in their descriptions of the hierarchical relationships of a laboratory. There is a quite identical spatial metaphor. A laboratory is like a

company or a factory: a laboratory leader (the professor) is at the top, the boss, Ph.D. students are managers, and the master students are the workers at the ground level. From the single leader on the top to the massive master students, it is like a pyramid.

Apart from the pyramid hierarchy, there is another spatial implication in the division of labor. The leader is in charge of making the formal research networks. These networks are the very possibility of the existence of a laboratory; without which a laboratory cannot have the financial, instrumental, and technical supports to survive. As for the Ph.D students, while the leader is the formal representative of a laboratory and its networks, Ph.D. students are developing networks in order to maintain the laboratory's formal networking outwardly and play the intermediately role between the leader and the master students inwardly. As for the master students, most of their works are focused on the experiments, but because of the practical reasons for using instruments, borrowing materials, and learning techniques, their activities do not limited within the laboratory and have their private networks as well. In this sense, the pyramid hierarchy stretch outwardly in the driftworks at every level and the agency of the members of a laboratory is made possible within these layers of overlapping driftworks.

The dual visions

There are two prevalent visions on the trainees' agency in these deployments. On the one hand, there is a functionalist perspective on what ability is required in order to have things done. The agency implied in this functionalism perspective is the technical (material and cognitive) ability to be achieved. It is very similar to the practice theme in STS that mainly focus on the making of objects and knowledge. This functionalist vision is in the comments from the laboratory insiders. For example, both students and leaders in the interviews talked about the training arrangements with such expressions like 'only solid training can produce good work,' and 'the arrangements are employed in order to have the result on time.' There seems to be an implicit agreement between the leaders and the students; in order to achieve the target, students have to follow the temporal and organizational arrangements that enable them to learn as soon as possible and work as best as they can, despite that for the students the 'target' is usually their degree and for the leaders the publication of a paper or a paten.

There is a difference between senior (the second year in their master studies, or when starting their Ph.D. studies) and junior students' responses to this. When being asked why they were doing the current work, because the juniors were still under training,

apart from the technical explanations, the junior students usually added that my seniors told them to do that or that they were assigned to do that. In contrast to that, the seniors usually explained the mechanism and the evaluation of various methods, and they could explain the relationships between their works and the others'. Furthermore, in senior students' account of the training, they usually said how stressful the process was and how they complained about the workload. However, when they talked about the juniors under their supervision, they became the pushy ones and sometimes complained that the juniors were not doing well enough.

In contrast, there is a critical vision on the laboratory training, despite that it is not commonly found in the interviews with the insiders. In fact, this critical vision is usually found in the outsiders. For example, in the beginning of our fieldwork and the first few meetings with my team, one of the most talked about issues was the way these students are 'exploited' and why they took the stressful training and the distribution of credits for granted. For sociology students in Taiwan, the critical traditions, especially those of Marxism, is so important that I believe the first few key words come to sociologists' minds to describe the situations are very likely to be 'alienation' for the division of labor, 'exploitation' for the distribution of credits, and 'false consciousness' for the students' consent on the functionalist account of their situation. Here, we have a complete different account of the arrangement and the experiences.

The agency implied in this perspective is not about the technical agency to manipulate things, but about the moral, social, and political agency (here after, critical agency for short) to free oneself, to fight against the powerful, and be able to make a difference to the social restrictions. From Max Weber's thesis of iron cage and Karl Marx's agenda of emancipation, such a critical perspective on agency is an important legacy in sociology and it remains an important thesis in the form of the dilemmatic 'structure and agency' debates in contemporary social theory. Looking into the critical agency of the trainees' from this perspective, the questions can be asked are completely different the functionalism; not about 'how they learn to do things?' but about 'how and why they do not and can not have alternatives?' The focus is not the functionally usefulness but the social control of the technical training.

The technical and the critical, these are the agencies from the paradoxical dual visions. I was troubled by them in the early stage of my research. On the one hand, the students seem to be agential: they learn and can do things, while on the other, they are not: they do not challenge the 'exploitation.' While most of the cases in STS

specialized in exploring the technical and practical aspects of how things can be done and how various forms of agency contribute to the process,³ sociologist interested in the moral agency that transcends the structural limitations or political agency that challenge the power. Being trained both in sociology and STS, I constantly asked myself: is it merely rehearsing the universal ‘production-exploitation-false consciousness’ mechanisms of capitalism in the field of science and technology? Are the students like workers who are also technically agential, but politically and morally incapable of forming a working class for itself and thus remain uncritical of the situation? Or shall I just follow the way STS scholars have done; focusing on the functional/technical aspect and leaving the critical aspect aside? Or is it possible to find a way out of the paradox that can explain both what make these trainees paradoxically (technically) agential and morally and politically un-agential that consent to the arrangement?

From paradox to driftworks of agency

Contemplating my dual visions, I found out that such a paradoxical dualism comes exactly from the division STS has been challenging: the division between the social and the technical. In this division, there are two modes of agency, the critical (social, political, and moral) and the technical, and the students are agential in the technical field and un-agential in the social field.

Further fieldwork on the trainees in practice suggests that the dualism comes from comparing insiders’ interviews and outsiders’ doubts are what actually happen *in practice*. In the fieldworks students take the harsh training for granted and help to enforce the institution in some situations, while they feel at lost and questioning the meaning of their work in some others. When they are involved in a particular training and working situation, they think and feel differently. Does it mean that the functionalism in their interviews is somehow an ‘ideology’ produced in situations to give a general account? Or what else way can we think about the functionalist account without the dualism? In other words, as students’ accounts of their experiences of the training and works in practice do not remain identical as those in the interviews do, how can we think about their different experiences of agency implied in these accounts in various situations?

³ In fact social agencies are common mentioned in STS when describing the heterogeneous works scientists and engineers have done in order to sustain the technoscientific facts and artifacts, but apart from emphasizing their equal importance in the making of science and technology, such as Latour’s (1988) claim of the interchangeability of material and social agencies in Pasteur’s work, these agencies are under-theorized.

In the following, I will explore their experiences in details and propose that, instead of the dual visions, the fluctuations of these trainees' agency is realized in the conjuncture of various influences; the diftworks of deployments discussed above.

Agency of limited transcendence

When taking the training deployments in practice into consideration, effects produced in the deployments seem to be quite paradoxical. As we can say that even the technical agency implies the ability and possibility of transcendence the current *technical* achievements, and in this sense the training deployments are enhancing the students' technical agency but paradoxically dis-abling the students to transcend the *social* organization, such as the division of labor. However, looking further into trainees' practices, it seems that the deployment of this technical agency is also of limited transcendence from the very beginning.

For example, in contrast to the functionalist idea of the trainings, when reporting the details of their works in onsite observations, these students usually talked about their researches with a very passive tone. They said 'my senior asked me to achieve these this week,' or 'the professor just drop this to me, and ask me to finish it within two days.' They felt that they were merely following the order and finishing the requirements from the professor or the seniors. It is also quite interesting that in interviews students talked about their project in terms of 'the research I am doing...,' but in onsite interviews of their practice the terms are 'the work I was assigned to do...' or 'my senior told me to try....'

This suggests that when reflecting on their actual practices, the students do not think they are doing *a research and exploring the unknown*, but been assigned to do *the works have to be done*, and this passivity sometimes produces a 'not my business' atmosphere among the students. Here is a case. According to his senior, James is a very enthusiastic and hard working student, and he is willing to tackle any problem. Nearly the end of his project, we observed how James constructed a circuit for his kernel of his system. Because of the complexity of the layout of the circuit he was in trouble for a long time. Finally, he consulted a Ph.D. student from another laboratory and took his advice; he used a coil as a small radio to replace part of the circuit for transmitting the signal. However, the solution did not work out straightforwardly since the radio also received background noises. After numerous tries, James finally solved the problem. After he has finished, we asked him how he did it, he said: 'I was just moving the coil around, and found out that the noises decreased in a particular place, but I didn't know why.' As we know that the junior students need to learn his

techniques and might even have to reconstruct his circuit, we kept asking: ‘you didn’t know why? Won’t this remain a trouble for the students going to continue your project?’ James replied: ‘I don’t care. It is not my business. I will have left by then. All I care is that I have finished what I was asked to do.’ This ‘not my business’ attitude of indifference is quite different from what he told us about the importance of the succession deployments in an interview, and is also contradicting the high evaluation from his senior. .

The agency leading to an end to itself

Semiconductor and computer-related industries are prosperous in Taiwan, engineers working in the science parks have been one of the most talked about new riches. Being trained in engineering, in the institutional design and their self expectations, students are fully aware of that that the training is supposed to lead to the life of being an engineer in the science parks. However, in this summer, two of the laboratories have graduated five master students, and according to the last interviews with each of them, only two of them wanted to work in the engineering. This shows another adverse effect from the deployments on the students’ agency; the better you know the work, the faster you want to run away. The agency deployed in these trainings is an agency that leads to an end to itself. This is shown both in their considerations of their engineering and academic careers.

As for their engineering career, for example, two of the students said almost the same thing about the two years and their future in different occasions. As for the research, they said that in order to get the degree, I would do and had to do what the professor asked me to do, but there should be a limit on this. I want to have my own life. As for the two years’ study, they said, it was like a warming up for living the life of being an engineer in the science parks, if you were comfortable with that then the science park jobs and the life style were for you, but that was not for me. One of them was considering going into the estate market, and the other favored the works need to mingle with people.

As for the effects on their research, such an agency is not enabling the students for further research as it should be, but even discouraging the students. This is shown in students’ thinking about where to stop the research, decision of what to do next, and consideration of their future if they are pursuing a Ph.D. degree. For example, as for their thesis, students who were finishing their project usually told us that they could get their degree when their supervisors thought that they had done enough. It means that, on the one hand, they were quite uncertain of whether their research did fulfill

the standard of a master degree. On the other, even worse, apart from their thesis project, some students even worried about that the laboratory leader might not want to 'free' them (fang-jen, 放人) if they are still useful to the laboratory, as if they are prisoners or hostages. Sadly, this did happen in one of five students. As for publishing the results of their research and the credits, most of the students do not think that is an honor, but as a further burden. That is because they think they are working for the degree; according to the division of labor described above, a master's work is about the manual work and the mental work, writing a paper about their data, is the work for a Ph.D. or the professor. As for their further study, a student told me that he won't consider doing Ph.D. in Taiwan because doing Ph.D. in Taiwan means that the student have to do the supervisor's project and can not do a topic that one is really interested in.

Driftworks of agency

In the above cases, we can see that the students are doing their 'works' passively just in order to get a degree. The training arrangements that are supposed to enhance students' research ability do not produce the compatible attitude to pursue the research. The students' technical agency emerges from the training deployment are of limited transcendence and might lead to an end to itself.

This is not saying that the functionalism vision is an ideology and that the students' critical vision of their situations can only be observed in their practices. I think that what I have observed is: agency is neither one dimensional, nor a constant property. Sure the students trained in these ways do become technically capable as well as sometimes become critical of the situation, but agency is more than these single aspects.

Just like that there are ups and downs in their experiments, students interpret their situation differently. Generally speaking, when things are going smoothly (shun, 順), students feel good about themselves and are less likely to complain about their situations, but in bad times, they complain a lot; even to the extend to make a fetish of the machine and think that that the machine and themselves are ill-fatted for each other (bu-her, 不合) or the machine is not happy with him/her (bu-swang, 不爽). This is also evident in the interactions with us. In the form situations, the students are either so concentrated in doing their works and have no time to answer our questions, or they are answering our questions and working cheerfully at the same time. In the latter, they are either so anxious that they sometimes asked us to let him/her concentrate on the work for a while, or simply quite and talked to us instead for a

break.

Taking these fluctuations into consideration, being agential not only has the technical implication of capable of doing something, which is commonly identified in functionalist vision, but also implies the willingness of the actor, the desirable result of action, and the alternative outcome; those intentional, moral, emotive, and political aspects. Even if we can say that the radical implication of agency is not usually observed (such as being critical and challenging the institution), but these emotive, intentional, moral aspects, and those related to everyday politics, are no less important in constituting the agency to achieve technical tasks.

These ‘subjective’ aspects are as objective as the technical one, for without which the actor is not motivated or unwilling to act at all. These ‘subjective’ aspects are neither subjective in the sense that I have a bad mood now and then but can be cheered up by a joke, nor subjective in the sense that I can switch my points of view on the same thing and have different evaluations of it. These subjective aspects are objective in the sense that they are consistent and have practical effects; as is shown in the above cases, it is the situations that make the actors feel bad or good, and are reluctant or willing to do what they are capable of doing.

Here, I want to emphasize that just like the technical capability, these ‘subjective’ aspects of agency are also deployed. On the one hand, as is shown in the above cases, the bad morale or even resentment is also resulted from the same training deployments. It means the training deployments have multiple effects; enabling and disabling the students are two of them. On the other hand, I feel that these adverse effects are not unknown to the insiders in the engineering, but in the current institutional design of engineering education, the most effective ways of alleviating or de-deploying the disabling effects are tackled at the individual level; some people employ their personal charm or extra care to initiate small scale deployments, such as the considerate professors and the seniors who not only teach the students how to finish their work practically, but also help the students with the pressure in the process.

For example, for the new students or the students struggling in their project, the day before progress report is usually full of anxious and fears. I talked to some of these students not performing well after the meeting, and one said that he was almost frightened to death and can not think of anything. Some senior students, usually Ph.D students, will help the juniors with a mock presentation in the pre-meeting for the first

few times, but even so in many cases students are still faltering in the formal meeting and sometimes they are so nervous as to talking nonsense and being unable to understand the professor's questions that they have already rehearsed. So the senior students not only have to teach the junior how to present, but also have to comfort them; giving them strategy in managing the professor, such as only release part of their progress in a time, and guiding the audience to the answerable questions in order not to being trapped in the stressful situation, etc. These senior students also have to stay late to accompany the juniors in the laboratory to prepare the presentation, and make jokes in order to cheer them up and encourage them. Sometimes, some professors are doing similar things by being nice and making jokes to students in order to ease the tension in the meetings.

There are many other such deployments involved in the process; these 'interpersonal' deployments are only some of them. Despite that many of them might not be formal institutions; these different 'subjective' deployments of trainees' agency are also part of the driftworks of trainees' agency. The scale of such deployments is small and their effects vary case by case, but these mini-deployments do have effects on the style of interactions between the laboratory members and gradually they are materialized into the different atmospheres of the laboratories. The ups and downs of the trainees' experiences of their agency is realized in the unfolding of driftworks of these deployments.

Conclusion: the realization of agency in the training driftworks

Based on the insights from STS on agency and my fieldwork, I have realized that the dual visions of the insiders and the outsiders are far too simplified and static pictures of what happens to the students' agency in the laboratory training.

Following the fluctuations in students' experiences about their projects, themselves, their future, and their situations, I have tried to suggest that the training deployments are not necessarily enabling; multiple effects are produced in these deployments. The trainees' experiences of their situations indicate that the 'subjective' deployments are indispensable to the realization of the technical of agency. In this sense, being agential is not only technically capable, but also related to the moral, emotive and political aspects, and that agency is realized in the driftworks of these deployments.

Given the discussion and the finding, a few words can be added with regard to the practical implication for engineering training. With the growing number of 'engineers of science parks' and the increasing popularization of the 'engineers' life style' (full of

work and computer games and do not know what to do in their private time) and ‘technician thinking style’ (lack of interdisciplinary thinking and creativity, and just react to the orders), the problems with the current ‘technical part first’ engineering education in Taiwan is emerging. Both outsiders and insiders are worrying about the situation. The government is looking for remedy by reducing the graduation credits of undergraduate to allow students to explore other interests, improving the general education in university to enhance engineering and science students’ knowledge of humanity and society, even launching STS teaching projects in order to bring in the interdisciplinary thinking. The Society of Engineering Education is also mobilizing accreditation schema in order to enhance the integrity of engineering education and hence better engineers who is able to and care about the social consequence of their profession. Even the companies are starting campaign for the dialogue between ‘technoscience and humanity’ in order to enrich the life of their engineers. From the undergraduate study to the working life, these measures are not necessary have the engineers’ agency in mind, but they do related to the concerns in this paper.

These measures all have to do with the deployment of certain aspects of engineers and the trainees’ agency. In order to improve the current the short sighted, technical aspect only education, with various intentions in mind, these measures end up focus on ‘adding’ something else to the technical aspect; whatever they are more personal time, more general education, more humanity enrichment, or STS thinking. Despite the good wills and the efforts, given the above examination of the fluctuations of trainees’ agency in the training driftworks, the laboratory training might be the kernel of making what an engineer is capable, and of making what the engineer is incapable of doing so as to fail to be what could have been become. As the adverse effects of the training deployments are currently alleviated by the individuals’ mini-deployments, in order to transform the engineers, it might be worth considering to re-deploy the training driftworks at the institutional level.