Methodolgy for Bridging the Brain and Body for Briliant Innovations

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***Abstract*—Medical doctors are likely to be clinically oriented due to monitory benefits and busy life schedule; therefore this reduces their interest in research and innovation. In order to increase the innovation interest, the School of Medicine, Universiti Malaysia Sabah has initiated a new strategy to fasten the research and innovation by CLIP Method. This concept is based on establishment of Creative Work Station, learning enhancement by Mechatronics Workshop, collection of innovative ideas and designing new projects. Preliminary results are given and further evaluation is required to establish the concept. Initial result shows that experienced physician's brain (knowledge & ideas) can be utilized by hands-on techniques (body activities) to get more creative ideas leading to patentable projects.**

Keywords-creativity; research; innovation; medical; prototype

I. BACKGROUND

Creativity is a key component to the long-term survival of a company [1]. Though creativity is popularly considered as in-born qualities of a genius, they can be nurtured and developed through continuous training [2]. An undergraduate senior level courses which were designed by University of Florida, "Creative Engineering I & II Sequence" were able to help in their institutions by training [3][4][5]. Despite the fact that there has been significant improvement in the healthcare industry, inefficiency still exists and little is accomplished in understanding how to overcome those inefficiencies using innovation in healthcare [6].

Creativity is a problem identification and idea generation whilst innovation is an idea selection, development and commercialization [8]. Innovation can therefore be seen as the process that renews or improves something that exists and not, as is commonly assumed, the introduction of something better [9]. All innovation begins with creative ideas and successful implementation of creative ideas within an organization leads to innovations [10]. In this view, creativity by individuals and teams is a starting point for innovation; the first is necessary but there is no sufficient condition available for the second [11]. Tidd *et al* [12], stated that there are four types of innovation; consequently the innovator has four pathways to investigate when in search for good ideas i.e. product, process, positioning and paradigm innovation. Innovation in healthcare is defined as those changes that help healthcare practitioners to focus on the patient by helping healthcare professionals to work smarter, faster, better and with more cost effectiveness [1].

Based on survey of 775 healthcare professionals from the US, UK, Germany and India [13]. In this it was stated that the problem is not a lack of ideas [1]. Difficulties lie in the diverse blockages to new ideas finding their way into widespread and transformative change [13]. On-the-job-training to keep healthcare executives and employees up to-date would increase their familiarity with technology and also enhances their likelihood of adopting new information technology [13] [37] [38]. This study summarizes all these facts as given below.

- Lack of ideas is not a problem.
- On job-training will enhance their likelihood of adopting new IT and generation of brilliant ideas.
- Lack of sharing ideas is always present therefore capacity to generate ideas can be enhanced by sharing.
- Sharing attitude will make project selection easier which leads to potent commercialise product.
- Another road block for doctors' innovation is lack of the venue whereby they can work on their innovation in hospitals or medical institutes.

CLIP Methodology is developed to overcome these road blocks. It is a strategy that bridges the brain (which is full of ideas) and the body (hand' skills) to come out with brilliant innovations. CLIP is designed from first word of the four components: **C**reative Work Station, **L**earning Skills, **I**deas Generation and **P**rototype Production. Therefore in CLIP Methodology, (C) is the venue, where learned skills (L) work together , to transform (I) into physical Protypes (P) .

II. OBJECTIVES

In view of the availability of different expertise in Universiti Malaysia Sabah (UMS) and the available facilities in School of Medicine, it was found that CLIP concept can circumvent the above mentioned problems that hinder medical practitioner's innovations. The comparison of creativity, innovation and CLIP methodology is summarized in "Fig. 1". The methodology focuses on idea creation, generation and selection. A provision of basic structure is required for the creation of ideas among medical personnel who were never involved in innovative activities. Therefore innovation directly starts from idea selection and creativity which is simply problem identification and then followed by idea generation. CLIP methodology creates comprehensive approach to produce prototypes projects leading to patentable products.

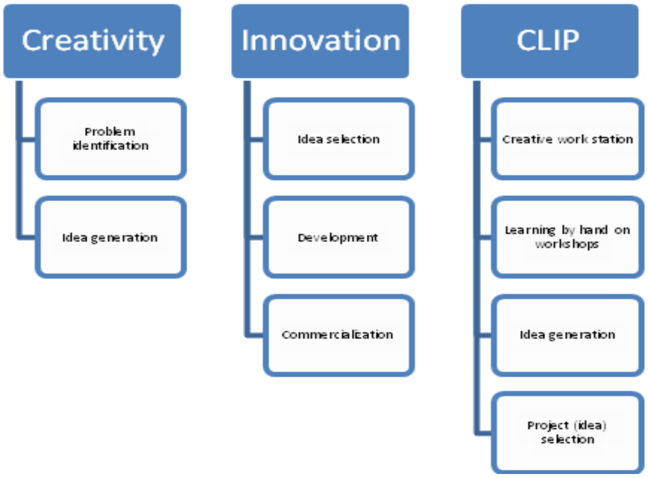

Figure 1. Comparison of Creativity, Innovation & CLIP

All school of medicine members are encouraged to join CLIP activities. They are referred here as MAST , where (M) stands for Management staff,(A) for Academicians , (S) for Students and (T) for Technical staff .

CLIP enhances the creative thinking and innovative attitude among MAST through various non-medical training programms [29][37]. The training programs (L) in CLIP apply the theory of multiple intelligences by Dr. Gardner [29]. Accordingly different potential pathways are chosen in (L) sessions, whereby the first Mechatronic workshop is to enhance the {Spatial intelligence} [30]. In other work, a pharmacy school taught electrocardiogram basics by using dance and movement {Musical intelligence}. In that trial the experiment was effective and had good learning outcome [31]. The technological arm along with the medical staff will narrow the gap between the practicing doctors and the technology which will definitely improve the practice and also facilitate innovating process. This will build a background of physical understanding and exemplary human physiology, which is beneficial for both the students and lecturers. Meanwhile, the engineers and other expertise who collaborate in such training (L) will get a new sense of understanding of the human body mechanisms [31]. The reciprocal discussion and sharing of experience will enhance coloration, which will impact on the development of new applications in robotics and biomedical engineering. CLIP will also enhance inter-university cooperation with other schools and institutes in UMS e.g., School of Engineering & IT, Biotechnology Research Institute and School of Science & Technology, Fine arts, Social science, etc.

Valuable trainings (L) and good facilities (C) will encourage MAST to participate in innovation competitions at the university and national levels. When the students (S) participate in the CLIP, they will have a better understanding of the rule of technology in the medicine and to improve learning process [14] . They also can use the technology to execute learning projects as anatomy models [35]. It is an important factor in their learning process, as 90% is retained in the memory if it is practically done. Although it is controversial, it is still commonly refereed percentage as the Learning Pyramid which was first published by an employee of Mobil Oil Company in 1967 in a Film and Audio-Visual Communications [13] [14][35].

Having the facilities to build up own protypes (P), will cut the cost, time and overcome the lack of facilities which hampers many of innovative ideas (I). These processes will enable the School of Medicine to have many prototypes which will support one of its main objectives.

III. MATERIALS AND METHODS

Wherever the targets are, a clear methodology is dependent on the available resources. Creative work station, Learning, Innovative ideas and Projects (CLIP Method) are its four components as described below:

A. *Creative work station (C)*

The need for it was recognized in the year 2008 when the authors started to transform the innovative ideas and projects into prototypes. It was initially difficult to develop it in the School of Medicine, as there was no venue for such type of hardware activities. During this period, their own facilities was used to for development. The same problem was also faced by many of MAST members, especially those who had no personal equipments to fabricate the prototypes. So having a work station would enable the user to transform the birillent ideas into feasible innovations. Creative Workstation started on May 2010. The committee which look after the (C) is the school's dean , and membership of 5 talented members from MAST . An academic member from School of Engineering and IT joined the committee as a technical consultant.
A spacious room was allocated as (C). The venue was renovated to support the developing basic hardware work.

B. *(L) activity of CLIP:*

The first mechatronic workshop was an introductory to the foundation for the mechanics and electronics.

The training was led by a lecturer from School of Engineering and supervised by 3 postgraduate students as technical assistants. The participants were divided into 3 smaller homogeneous groups. Among these groups, each pair had to accomplish their own mini project.

Robotic Research Laboratory in School of Engineering was selected as the venue. The wrkshop was held for two successive days.

Training Structure: The technical skills (L) are ranked in different levels from the basic to advance. All participants should first join the basic mechatronic workshop to be exposed to basic technological skills.

The planned knowledge and skills were managed to be integrated with the attitude (Schön, 1983) of the participants to achieve the goal [37].
The workshop had 4 main themes as given below.

a) Safety of mechanical tools and electronic devices
b) Basic electronics and circuits.
c) Basic sensors.
d) Basic motor and control.

The objective of this introductory workshop was to expose the participants to the basic skills in handling different materials. They were exposed to wood and metal work. The basic wood work skills were (drilling, cutting with different saws, gluing and measuring). While in metal work, they practiced (cutting with different saws, metal drilling, riveting). This also later covered the basic electronics skills (soldering, reading circuits, identifying components, testing current and voltage) [39] [40]. Each theme is covered through a one hour lecture followed by 3 hours of Hands-On session. The four lectures enabled the participants to understand the basics, application of the electronics and mechanical integration gradually in a comprehensive way. The outline of the workshop is shown in Table 1.

TABLE 1. THE OUTLINE OF 1ST BASIC MECHATRONIC WORKSHOP TRAINING

Theoretical	Hands-On		
Lecture title	Wood skills	Metal skills	Electronic skills
Safety, tools, equipment	G1	G2	G3
	G2	G3	G1
	G3	G1	G2
Basic electronics and circuits	G1	G2	G3
	G2	G3	G1
	G3	G1	G2
Basic sensors	G1	G2	G3
	G2	G3	G1
	G3	G1	G2
Basic motor and their control	Free time to finalize the end product		

The Hands-On sessions provided ample of time for basic demonstration, practice and troubleshooting and problem solving. The personal guidance was given for the participants. The three hours session was also divided into a three hourly slots. The participants were divided into three smaller homogeneous groups and were rotated every hour through three stations for better involvement. This allowed them to apply what they had learned in each lecture and demonstration to complete their mini project. The participants completed their mini project based on the skill learned with the assistant of the tutors since it was the first time many of them were exposed to these technical aspects.

C. *Innovation Ideas (I)*

At the end of workshop, MAST came out with some innovative ideas. After data collection by unbiased innovators of the university, the potential projects were selected. Analyzing these (I) is an important step to determine the appropriate way to develop it. Some of the innovative ideas could be developed into prototypes within available facilities. Meanwhile, big scale projects required research grants for development.

D. *Project and Prototypes (P)*

Developing of the selected innovative project took place in the creative workstation. The environment was suitable for more experiments and modification. The engineering consultation provided in formal and informal ways to support the development of each prototype. The projects which required special skills and facilities were planned to be executed in engineering school workshop.

IV. ASSESMENT

For evaluation of the cognitive outcome of the workshop, a pre and post training questionnaires were distributed to the participants to analyze the cognitive outcome of workshop. The questionnaire consist of 10 multiple choice questions. These questions are based on the theoretical and practical aspects of the workshop learning objectives.

Meanwhile the practical outcome was monitored throughout the four sessions whilst the participants were constructing their final projects.

By the end of the workshop, a feedback form was distributed to each participant to indicate what the participants liked and disliked in the training and its suitability for their needs and expectations.
(I) are also discussed after the workshop, to be developed and modified in preparation for (P).

V. RESULTS

A. *Creative work station:*

The current workstation has a surface working area of 12 meter^2. It is suitable for most of the heavy and light hardware projects. It is well ventilated and has proper lighting and storage areas. The basic tools are available to work on the convenient materials which is mostly used by any casual user. It is planned to be upgraded in the future in responds to the need and shortage which may be encountered during large scale of practice. Materials and consumables were provided such as: cartoon boxes, light wood, foam, plastics, aluminium sheets and electric circuits.

B. *Learning: Outcome of 1st Mechatronic workshop*

1) MAST distribution :

It is found that there is almost an equal interest between the males and females, above and below age of 40 (Table 2)

TABLE II. AGE AND SEX OF THE PARTICIPANTS IN MECHATRONICWORKSHOP

Total	Age Distribution				Sex Distribution	
	>20	>30	>40	>50	Male	Female
23	8	3	4	8	11	12

A total 23 applicants out of 39 enrolled applicants managed to accomplish the two days training program due to concurrent events on these couple of days (Table 3).

TABLE III.DIFFERENT CATEGORIES OF THE PARTICIPANTS IN MECHATRONIC WORKSHOP

Category	n	Notes
Academics/Lecturers	15	4 lecturers attended 1 day training
Non academic MLT Staff	3	A concurrent meeting for administrators held on same dates
Management/Admin	1	
Students	4	6 students could not join the training because of other commitments

2) Practical outcome:

A total seven final models has been accomplished after 4 hands on sessions. It is actually 80% of the expected projects. Those who accomplished the practical projects were excited and showed great enthusiasm. The project is to develop a wooden box with metal bar attached which houses a developed electronic circuit that will be activated by light to on a small fan.

3) Cognitive outcome:

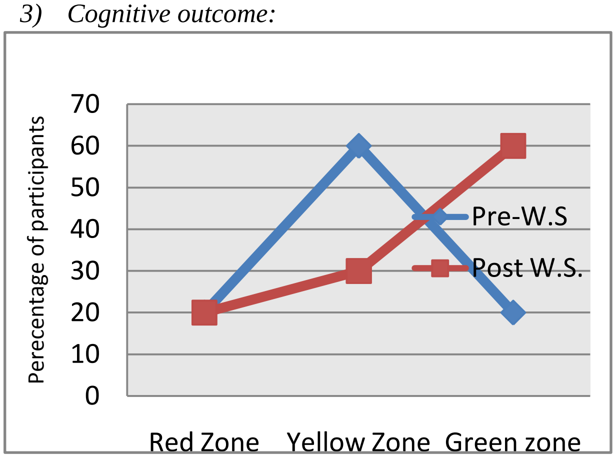

Figure 2. Comparison of the cognitive outcome of the Mechatronic workshop: post W.S (post-workshop) assessment to pre W.S. (pre-workshop) assessment

The results of pre and post workshop test showed a significant improvement of participant's technical awareness. As a standard for evaluation, we considered the score of < 30% as red zone, less than 60% as yellow zone. . The cognitive outcome of post mechatronic workshop is shown in ' Fig. 2"

While more than 60% as a green zone. In the post workshop assessment, the percentage of participants who scored in the green zone was 60%, in comparison to 20% in pre-workshop assessment. Meanwhile red and yellow zones significantly narrowed from 20% and 60% during pre-workshop into 10% and 30% during the post workshop respectively.

4) The participants concern of the learning outcome

All the participants (n=18) were provided with an evaluation form (feedback) at the end of the two days' workshop. The feedback consist of four structured questions to rate the different aspects of the workshop. The 5th question was an open question to express their opinion. Presented here are the results of the evaluation for each question.

The first question of feedback was to survey the overall impression regarding the overall workshop . As shown in "Fig. 3 " , the participants were impressed with exposure to this technical skills. None of the participants provided negative ratings like poor or fair.

Figure 3. Overall impression of Medical School delegates on Mechatronic training

The next questions were to evaluate the program structure and suitability for its objectives are summarized in table 4 . It is rated excellent and good by the majority. As they came to understand how to design a project and to translate the idea to action. In the response to cognitive and new practical skills outcome , most of the participants rated very good or excellent . Most of them were exposed for the first time to such skills . The participants found the new skills are relevant to professional practice and could be applicable in future projects , as shown in " Fig. 4 "

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The 5th question gave the participants an opportunity to state what they liked and disliked about the workshop and what improvement to be made in the next training session that they would like to suggest. Varieties of positive comments about the experience of the 2-days training program were recorded.

TABLE IV. THE PARTICIPANTS FEEDBACK REGARDING MECHATRONIC WORKSHOP OUTCOME

Parameter score (m)	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score mn=72
Program Structure	11	7	0	0	65/72 (90.3 %)
New Knowledge	12	6	0	0	64/72 (88.9 %0
Relevance and Impact	11	7	0	0	65/72 (90.3 %)

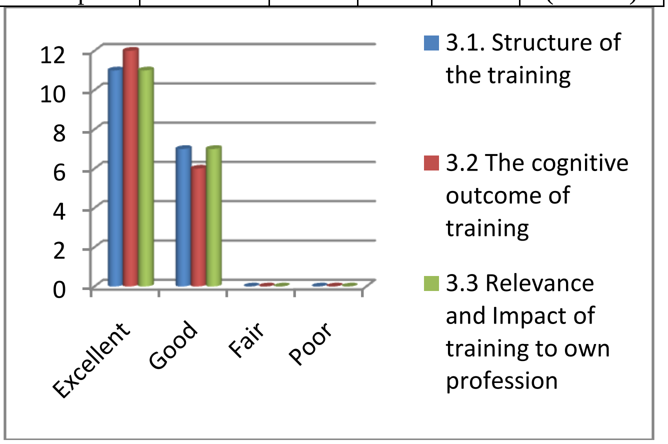

Figure 4. Feed back of participants regarding the contents of the training program

Majority of the participants liked the brain storming atmosphere during the workshop. They expressed that (L) provoked their interest to think out of the box in different aspects . 50 % of them liked the hands-on sessions. 38.8 % was impressed with the lectures, methods of training, new learned skills and knowledge. 11.1 % of participants admired the innovative and interesting training contents.. Academicians were motivated and energized by these technical training. The favorable comments ranged from "The final product is encouraging and comprehending, the training gives clear understanding of the principles, it is challenging, it is great, best workshop attended so far etc." to "it is well organized and properly prepared".

Meanwhile 22.2 % provided negative feedback regarding the shortage of allocated time to finalize the end-product. Another participant expressed about whole day session, especially in post-lunch session . Others pointed out about some shortage of tools , which had been shared .

Many constructive suggestions for the next training sessions came out. Few participant suggested to extend the training period , " from to 3-7 days in a camp like status" . 4/18 suggested to "introducing more medical applications in the program".

2/18 were interested in joining the "advanced level of technical learning in the program". Another participant suggested " to hold the program frequently to give chance for a more to participate". In view of the groups distribution , one student suggested that "each working group to include academics and students together".

C. *Innovative Ideas:*

Out of twenty three participants, seven innovative ideas were laid out as a result of brain storming and exposure to new technical skills. All the ideas came from the lecturers who attended the workshop. Immediately after the workshop, four of these ideas had further study and consultation. (I) underwent modifications and adaptation to transform it into action.

D. *Projects and Prototypes:*

The designated four (I) had the challenge to participate in PEREKA 2011 (Research and innovation competition) at the university level. The four projects had been transformed into protypes using the knowledge, expertise outcome of the mechatronic workshop. As a fruit of (L) , expertise consultation was accessible. These projects came out of academic category (n=15) (26.7 %) over period of three months. Most of the innovators used Creative workstation facilities to accomplish their projects, namely as follows:

1) "Scrubbing and sterilization protection sensors (SPS)".

2) "Teaching aid anatomical model for neural motor pathway in the upper limb"

3) "Amplifier for fetal heart sound for clinical purposes in remote areas and for teaching demonstration." This project has applied for a grant for further development.

4) "CLIP Methodolgy"

Three projects were awarded gold, silver and bronze medals in an PEREKA 2011 (University Innovation competition) on 7th June 2011.

VI. DISCUSSION

Most of changes in the medical practices evolve around science-based health innovation . CLIP methodology aims to encourage the innovation in health services ,which is the synergism of innovative professional products and academic tools ' Fig. 5 "

The professional innovated products vary across a spectrum of sophistication, from vaccines, pharmaceuticals, IT (Information Technology) applications, medical devices to some plant medicines [27] [28]. While in the academic institutes of Medicine, the innovation inputs lead to innovated academic tools as researches , teaching aids and teaching methods [7].

It is an opportunity for lecturers (A) and other MAST categories to go for continuous professional development

[36]. It sharpens the saw of different intelligence of the participants and releases the stress, anxiety and encourages the spirit of learning [35].

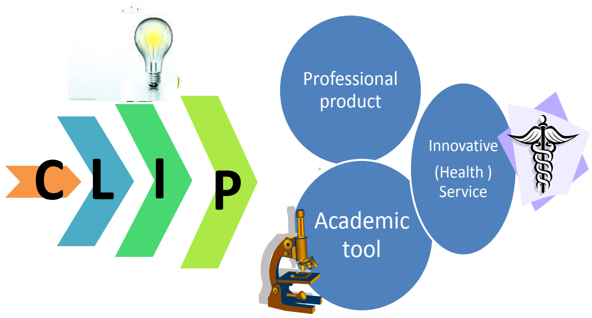

Figure 5. CLIP methodology enhances innovative health services. (C) Creative work station is working venue, (L) learning supplementary skills, (I) Innovative ideas, (P) Prototype production.

Initially , ten students (S) were eager to join the training , but only four of them attended the (L) session due to concurrent school activity. These participants showed enthusiasm and got the highest scores among MAST in post workshop assessment. They expressed their wishes to attend the advanced mechatronic workshop.

When (A) and (S) are involved in the (L), new innovative ways in teaching and learning process develop. Accordingly, it becomes most effective than the dry lectures and boring text books [32]. Exposure to these parallel skills will challenge students to think critically, communicate lucidly, and to think out the box to understand their own curriculum [14][33].

Some academicians (A) had shown some uneasiness on the concept of CLIP as (C) is hardware workshop and (L) content as {mechanical and electronic skills} does not fit with the medical curriculum. Others were afraid to enter unknown area of technical knowledge since most of them are engrained as medical personnel.

Meanwhile many academicians encouraged this new challenging concept. In this preceding trial, 15 academicians (A) had participated in first learning session (L). The post workshop feedback revealed the participants' appreciation to such non-medical skills. Some of the lecturers found it is so interesting to use electronic principles and experiments to teach complicated medical concepts in physiology.

(C) Provides not only the venue, tools and materials for prototype production, but also the consultation services. These facilities had been used effectively to execute some projects. A plan is done to maintain and upgrade (C) to fit different styles of innovations.

A list of (L) skills were chosen to meet the MAST needs and to develop their talents [13][38]. From post workshop feedback, it is clear that longer time for the workshop and additional tools in hands-on session will improve (L) outcome in term mastering the new skills .

The School of Engineering started to apply the structure of (L) ,as a preliminary course for all first year students.

As the trainings are run by collaboration with the expert people in their professions, it stimulate personal and professional growth [31]. The collaboration is a healthy environment that allows the exchange of experiences between engineers, doctors; artists, musicians, architecture and IT people will enrich the university environment known as hybrid learning environment [33].

As a preceding work, other trainings will be arranged in collaboration with experts in the university to enhance MAST` multiple intelligence as: medical photography, fine arts, music, in addition to the advanced mechatronic workshop [29][30]. In this advanced workshop the applications of technology in daily used medical equipments will be highlighted in depth e.g. Fiber optics, endoscopy, manipulating and acquiring medical data. Micro-controller programming which is used in robotic arms will also be covered [39][40]. Such workshops may be a seed for a proposed Bio-Medical Engineering program in the university.

Most of the developed (P) are teaching aids, while the professional (I) had not been translated into action as yet [34]. Through CLIP, synergizing medical basic sciences, clinical medicine with learning (L): non-medical skills in technology is expected to lead to more innovation in health services as shown as in "Fig.6".

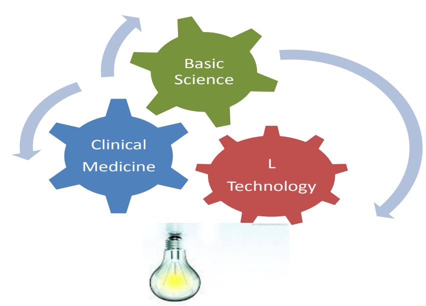

Figure 6. CLIP methodology: Synergism of (L) : technology, basic sciences, and clinical medicine, will lead to more innovation in health services

One intrinsic weakness in this study is limited number of participants MAST. Accordingly further work is required to show statically the impact of CLIP on both academic and professional fields. Persistence of different modalities of training and participation of more candidates of MAST will clarify the effectiveness of this innovative methodology [26]. Other limitation was the limited number of some tools in relation to the number of participants in (L). The present (C) is relatively small and upgrading is required to be able to accommodate transformation more (I) into (P) products. "Innovation is like riding a bicycle; you must keep pedalling or you coast. And, the only way you coast is downhill" [15]

VII. Conclusion

CLIP methodology provides the venue, facilities and consultations for the members of the institute to execute

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their own innovations. It also exposes them to parallel skills which sharpen their talents. This paradigm gives them the chance to translate Knowledge to Action. In the last 10 months of the activity, brain storming towards innovation had been provoked in the school of medicine. Some innovated projects had been completed and awarded at university level. As a preceding work, a variety of trainings programs such as medical photography will be arranged in the future. CLIP Methodology is potentially suitable for the schools with comparable infra-structure and problems e.g. biology and geology institutes .It is hoped to be an effective methodology in enhancing creativity and innovations.

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