An Effective & Efficient Implementation of OBE Framework within Constrained Pakistani Environment to Attain Desired Learning Outcomes

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Abstract

Outcome-Based-Education (OBE) is an academic model emphasizing on a curriculum framework that outlines specific measurable outcomes. OBE is committed to provide education that embeds required learning-outcomes in the students at the end of any degree program; which is indispensable for pursuing the advance education in related discipline and/or to tackle the practical problems of industry. Following the several inherited advantages of OBE system, Pakistan Engineering Council (PEC) introduced it in local engineering Higher-Education-Institutions (HEIs), from 2018, replacing previously followed Syllabus and Curriculum-based education system. The previously followed system only requires satisfactory completion of curriculum in contrast to the OBE system that demands achievements of certain learning-outcomes of all the courses in the curriculum, to graduate the degree program. Therefore, procedures and methodologies followed in the former system cannot be used as-it-is in the OBE system. However, some HEIs are still following the old procedures in adaptation of the new system, which eventually leads to failure of the OBE system. One of the major hindrances in adaptation of the OBE system is the lack of effective control, without which learning-outcomes cannot be achieved. It is thereby very crucial to introduce a well-defined OBE framework, along with the aggressive administration from the higher academic and administrative bodies to play their role in making the HEIs strictly follow the OBE framework. Also, it is equally important to identify/rectify the wrong practices followed by different HEIs. This whole implementation problem along with its side effects has been thoroughly discussed in this paper as a main scope. This paper also aims to present a strategic solution to the highlighted issues by employing the feedback control theory. The paper therefore presents a two-fold contribution. First, the implementation problems of the OBE system are critically analyzed. Next, few modifications in the existing approaches have been introduced to achieve the desired results from the recently adopted OBE system.

Index Terms: Academic Control System, OBE-Framework, OBE System Implementation, Outcome-Based-Education, Undergraduate Engineering Program.

I. INTRODUCTION

Undergraduate or bachelor of engineering studies is the most fundamental degree program in the cadre of higher engineering education. After successful completion of the degree program, the engineering graduates are expected to be fully equipped with the knowledge of; Fundamental Engineering Principles, Basic Engineering Methods and Techniques, and the relevant Technology of the respective discipline. Any deficiency at this stage is irrecoverable, and it would cause disablement of the graduates in perusing higher studies, and in practicing engineering in industry. Keeping in view of the importance of the degree program, it is needed to give special care in carrying out these studies. The Outcome-Based-Education or OBE system can ensure attainment of all the required goals of the degree program, should it be properly implemented. Owing to its popular merits, the Pakistan Engineering Council (PEC) introduced the OBE system in Pakistan, by signing the Washington Accord.

The Washington Accord, created in 1989; is an agreement to accept undergraduate engineering degrees that are obtained using OBE method. Initially, it was adopted by countries like Australia, South Africa, and United States in early 1990s [1-4]. It was followed by the other countries like Hong Kong, Malaysia, and that of EU [5-7]. By the end of 2017, several countries come onboard as the full signatories including, Canada, Taiwan, Pakistan, India, Ireland, Japan, Korea, New Zealand, Russia, Singapore, South Africa, Sri Lanka, Turkey, China and the United States [8].

The OBE system has a widespread acceptance all over the world due to its inherited benefits that include student involvement, clarity in learning objectives, flexibility of teaching methods and comparability by different institutions. Despite of this fact, several cases of phasing out this mode of education have been reported [6]. The reasons of this phase out and associated problems faced by these countries are discussed and analyzed in depth in the references of [1-6]. There are many reasons for failure of
the OBE system, the main reason had been the vague assessment system, and un-thoughtful implementation of the OBE system, without considering the local conditions and ground realities. It is worth mentioning here that, despite of having highly qualified teaching faculty (PhDs) and state-of-the-art resources in their bachelor-degree programs; most of the developed countries (like Australia) have to face the failure in adopting this system.

Provided the fact that OBE is a student centric approach, that not only emphasizes on the achievements of the student at the end of any degree program but also provide some pre-defined parameters to evaluate the said achievement. Several works in the literature are found that emphasizes on the implementation of OBE system and the associated teaching methodologies in different countries of the world [9-14]. Since the HEC of Pakistan introduced OBE to local universities in late 2015, author Kamran and his colleagues discussed the implementation scheme of OBE system under constrained local Pakistani environment [15]. Accordingly, a detailed analysis of transformation from teacher centric (conventional mode) to OBE is presented by author Manzoor and his colleagues [16]. In contrast to these works, this paper aims to highlight the ways and means to achieve benefits of OBE system implementing, within local (Pakistani) circumstances, and avoiding the failure due to its weaknesses, by taking preventive and corrective measures. The remainder of the paper is organized as follows; Section II gives a brief idea of OBE system, followed by the brief explanation factors it involves. Section III states the key problems along with the OBE framework; in the next section i.e., Section IV, the proposed solution has been stated. The Section V gives modus operandi of the proposed solution. Finally, the conclusion is made in Section VI.

II. BASIC IDEA OF OBE SYSTEM

The OBE based system degree program comprises of three main objectives; Program Educational Objective (PEO), Program Learning Outcome (PLO) and Course Learning Outcome (CLO). All of these outcomes in an OBE system are well defined and known to both students and teaching staff. This is to ensure that each of them is aware of the fact that after the completion of a degree program, a certain set of skills should be achieved by each candidate. Therefore, OBE is defined as a closed loop system and needs a continuous check and balance on yearly basis. Academic authorities of the HEI prepare a report known as Self-Assessment-Report (SAR) for each degree program, which is evaluated by accreditation bodies (such as Pakistan Engineering Council, in Pakistan) for the certification of the degree program.

III. MAJOR PROBLEMS IN EXISTING SYSTEM

In the syllabus and curriculum-based education system, some of the teachers used to teach selective portion of the syllabus with more emphasis, which is of their main interest. And in doing so, sometimes they ignore to teach important portion of the syllabus. This would result in incomplete knowledge (or learning-outcomes) attainment by the students at the end of the course. In absence of an effective regulatory mechanism this practice could not be corrected in this system. Because of the several inherited advantages of OBE system, PEC introduced it in local engineering HEIs, replacing previously followed syllabus and curriculum based education system. The previously followed system only requires satisfactory completion of curriculum to graduate the degree program, in contrast to the OBE system that demands achievements of certain learning-outcomes of all the courses in the curriculum. Therefore, procedures and methodologies followed in the former system cannot be used as-it-is in the OBE system. However, some HEIs are still following the old procedures in adaptation of the new system, which eventually leads to failure of the OBE system. Following are the main problems which are a result of the faulty implementation of the OBE system:

A. Weak CQI Mechanism

Figure 1 shows a functional block diagram of OBE framework [17]. It is clearly evident from the figure that OBE system is a Multiple-Input-Multiple-Output (MIMO) academic feedback system and it makes Continuous-Quality-Improvement (CQI), in a changing environment, to meet the OBE’s objectives; PEO, PLO and CLO. Quality Enhancement Cell (QEC), along with other academic bodies like Board-of-Studies (BOS), Board-of-Faculty (BOF) and Academic Council (AC), is supposed to be responsible for the executing of CQI process. In the presence of effective CQI mechanism, it is very unlikely that the OBE might be failed. However, the poor implementation of OBE system can result in; inaccurate measurement and faulty evaluation of learning outcomes, and thus it would result in flawed ‘CQI’ control-actions. Consequently, the achieved learning-outcomes would gradually diverge from their required levels, and if the trend is not checked, the whole system can go vagrant and can be failed in due course of time.

![Figure 1: Block Diagram of OBE System Framework](image)

The three OBE system parameters (PEO, PLO, & CLO) are coupled variables, i.e., these parameters are interlinked with each other, and the system, is therefore a coupled MIMO system. A professional and intelligent approach is required for the CQI mechanism that may give desired...
results. Like all coupled-MIMO feedback systems, the OBE system can only be beneficial, if-and-only-if all of its individual parameters meet their set targets. Therefore, it is required that all three parameters (PEO, PLO, and CLO) should achieve their desired peaks, within specified time-frame. In these three parameters, the high achievement of PEO by the HEI graduates is very much dependent on their academic training and hence reliant on good performances of rest of the two outcomes; PLO and CLO. Therefore, it is inevitably required that later two parameters (CLO & PLO) should have an effective feedback-control-system under strict monitoring and control of the academic officials (with well-defined responsibility and authority). Incorporation of an inner-feedback-control-loop, within the OBE framework, will not only make CQI action more efficient, but it will also help in achieving the desired learning-outcomes accurately.

B. Inaccurate Assessment Process

a) Deceptive Assessment: Vagueness of assessment, of OBE system parameters, is considered as one of the major flaws of the System [18]. Implementation of OBE system following a classical semester system approach, in which the course in-charge has unbridled assessment authority, makes the problem worst. Especially when the students succeed to deceive their assessors by using unfair means in the sessional-tests (like; midterm-tests, quizzes and assignments etc.). Incidentally, this assessment authority cannot be altered, as per very nature of the semester system. Consequently, due to unavoidable “human error”, some students (or graduates) clear the course (with flying marks) without achieving all learning outcomes. Eventually, this causes an irreparable damage to the society. Therefore, it is required that human-based assessment should be coupled with an unmanned or auto-assessment to filter out the phony graduates from real ones.

b) Course Topics Wise Assessment: There is another factor which makes the assessment faulty. Some teachers assess their students for all topics of (old) syllabus, instead of assessing them for the real learning-outcomes. For example, syllabi of engineering courses include math topics also, therefore questions made on these math topics only is a wrong practice. It has been observed that some of engineering graduates gained expertise in simulation and mathematical tools, and having very poor knowledge of engineering basics. Therefore, CLOs must be properly defined and questions posed in tests, assignments and quizzes etc., should be based on them. Otherwise final assessment will be inaccurate and will not reflect achievement of real learning outcomes. Main cause of this problem is unscrupulously defining CLOs derived from old syllabus of the subject course. Knowledge of; engineering-principles, engineering-methods, or engineering-techniques etc., should be the learning outcome of an engineering course. Pure Math-topics based CLO definition is a wrong practice. Academic managers should check and correct it, the QEC and OBE cell experts can help them, in this regard.

IV. PROPOSED IMPLEMENTATION SOLUTION

The objective of OBE system is to achieve desired learning-outcomes (CLO & PLO) from Teaching-Learning (or Pedagogic) system. Achievement of the goal is not possible until enforcement of an effective regulatory mechanism on its operation. This will assure that; all CLOs must be covered in teaching the course, and also, the assessment should be made on all of the learning outcomes. Therefore, it is required to introduce an inner feedback control-loop in the OBE framework (Figure 1). Secondly latest technological aids should also be employed to improve performance-efficiency of the Pedagogic system and to assure accurate assessment of the learning outcomes. The solution will help the overall CQI mechanism to correct the Pedagogic system if it deviates from the reference trajectory, and will make it to achieve desired learning outcomes.

Thus the proposed solution to the regulation and the CQI problems consists of following two components:

- Introduction of an internal-feedback-control-loop for the academic activity.
- Employment of latest technological tools for the Teaching-Learning and Assessment activities.

A. Internal Feedback Control Loop

Design of the internal feedback control loop is derived from ‘Control Theory’. Therefore, it is appropriate to describe the relevant part of the control theory before explanation of the control-loop design.

a) Feedback Control Theory:

An author Stefan Simrock defined the control theory as follows [19]:

“In engineering and mathematics, control theory deals with the behavior of dynamical systems. The desired output of a system is called the reference. When one or more output variables of a system need to follow a certain reference over time, a controller manipulates the inputs to a system to obtain the desired effect on the output of the system.”

Control theory is basically based on following two fundamental postulates (which are being used for designing of the academic-feedback-control system):

- In absence of any control action, it is a very rare chance that even a perfectly made system would give the required performance when it is operating under influence of external/environmental forces.
- System cannot control itself; it always needs an external controller, which influences the system in such a way that it gives required performance.

Remark: Another important premise of system theory is derived from Principle of Inertia, (which originated with Aristotle for "motions in a void", states that an object tends to resist a change in motion). The premise, being
used by system states that all systems offer resistance to change in their present states, i.e., all systems tend to endure their present states of operations and they do offer resistance to any external influences or control forces which tend to change the present states.

b) System to be Controlled:
In old (annual) education system ‘Teaching’ and ‘Learning’ were two distinct activities, however modern (semester) education system fused both of these activities into one unified ‘Teaching-Learning’ activity. It is to be noted that aim and objective of the OBE system is to attain required ‘Learning-Outcomes’ by the students and graduates. However, students’ learning is dependent on their active participation in:
- Class-Room Lectures,
- Learning-Activity generated by the Course-in-Charges (and their team of; Teaching-Assistants and Lab Assistants).

Therefore, students-group cannot be separated from its teachers, and consequently the ‘Teaching-Learning’ system can be considered as one unit – the Pedagogic system. Following the second postulate of control theory, the Pedagogic system cannot control itself. That is, in absence of appropriate external control actions, it cannot achieve the desired outputs, especially when it is operating under influence of external influences (like; deviation of set plan by the teachers due to personal reasons, and use of unfair means by the students). The Pedagogic system is a human-system, and each member of which has different nature. It implies that the system-to-be-controlled is random in nature, and therefore it requires an adaptable intelligent controller for its control (or management). Fortunately, variation in the members of the system is known and bounded.

c) Design of Internal-Control-Loop:
Topology of the internal-feedback-control-loop for the academic activity, within the OBE framework, is illustrated in Figure 2. It is a typical Two-Input-Two-Output (TITO) vectors feedback-control-system aimed to minimize the error between desired and achieved outputs. The ‘Academic Controllers’ (or Academic Managers) are required to consistently monitor, evaluate and intelligently control the academic activity, such that the errors between required-learning-outcomes (CLO<sub>k</sub> & PLO<sub>k</sub>) and achieved-learning-outcomes (CLO<sub>λ</sub> & PLO<sub>λ</sub>) should become minimum possible. The ‘Course-Reports’ are being used as a ‘Feedback Element’, which shall be prepared by the course-in-charge, in the format of “course files” of PEC Manual of Accreditation (pp. 30-31) [20]. On the basis of reported assessment of attained output parameters; CLO<sub>λ</sub> & PLO<sub>λ</sub>, (in feedback) the academic controllers (or managers) will evaluate the process-performances against the desired goals and will take appropriate control actions for minimizing the process errors. Thus the main role of the controllers is to take appropriate control action; to reject the effects of external influences, and to make the Pedagogic system to follow the reference inputs (CLO<sub>k</sub> & PLO<sub>k</sub>) with negligible steady-state errors within minimum transient-time.

d) Inertia of Humanoid System:
Transient time primarily depends on inertia of the System-to-be-Controlled and it is main hurdle in initial control phase. Fortunately, unlike machines, inertia of human beings is not rigid, as they have capability of learning and adaptability. However, it requires constant application of controlling efforts to develop their adaptability with controlled-environment. Carrot-and-stick policy is an established controlling instrument. Therefore expert Academic Managers can adroitly handle this impediment, and with their consistent efforts, all the control objectives would be achieved in minimum possible transient time – that is, minimizing the steady-state process errors to a negligible value, and thusly achieving all the required Learning Outcomes.

**Remark:** Once the Pedagogic system is adapted with the controlled environment, it will respond immediately to the command inputs (without any hesitations or delays). Even in this situation, control-pressures must continuously be applied on the System; otherwise, in its absence, it will go back to the square-one. (Because of elastic nature of the human-inertia, it will re-adapt itself to the most convenient or relaxed position.)
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     e) Impact on CQI Process:
     The cycle-period of the Course Report based inner-loop is one regular semester. Whereas the cycle-period of SAR based overall OBE loop is one academic year. Therefore, Assessment, Evaluation and Improvement (or CQI process) will be made twice a year due to inner-loop, by the HEI’s own academic managers, and once a year for whole OBE cycle, by the Academic Experts of the accreditation body. It implies that the frequency of the CQI process will be tripled due to introduction of inner-control-loop. Hence, the attainment-speed of the required OBE system objectives will become much faster due to introduction of the inner-control-loop.

B. Employment of latest Technology
   a) Teaching Learning Aid:
      Use of Teaching-Learning technological aids and Learning-Management-System (LMS) type IT tools can greatly enhance performance efficiency of the Pedagogic system, and therefore, it is highly recommended for their employment. LMS associated data-base tools are helpful for; data-recording, its analysis, and report-generation of semester sessional activity. It also provides an interactive platform (for 24/7, through internet) to all stakeholders of OBE system, especially the students and the teachers. Thus the use of technological learning aids can enhance performance efficiency of the Pedagogic activity, and can help in accurate assessment of OBE system parameters.

   b) Unmanned Testing System:
      Conduction of MCQ type filter-testing, on an unmanned auto-assessment testing system, is an essential requirement for minimizing human-error in students final assessment. Students’ active participation in academic activity is expected to result in learning of basic principles of the course. The test will determine this outcome. Fortunately, auto-assessment or machine testing facility is available in all of the local engineering HEIs, and they administer such kind of auto-assessment tests in their admission process. The diagram shown in Figure-3 illustrates the mechanics of the overall proposed solutions. Besides illustration of flow of the control process of the Teaching-Learning (or Pedagogic) system, it also shows the role and approach of different academic and non-academic bodies and that of technology-support in solving problems, which were discussed in Section III and in the SectionVI.

V. MODE D’EMPLOI OF PROPOSED SOLUTION
   In the previous sections various facts are investigated and are accordingly stipulated to make final remarks on the implementation of the proposed solution. The remarks cannot be treated as a final verdict; however, these can be helpful for achieving desired objectives of OBE system.

   1) The sessional academic activity should be monitored and controlled by the Academic Managers, that is; Head-of-Department (HOD), any Academic Body (like BOS), and the Dean of University [or Principal/Head of Institution (HOI), in case of University College].

   2) Besides simple class Lectures and Labs, the semester-session should have sufficient learning-cum-assessment activities like; Tutorials/Tests, Assignments and Quizzes etc. Performance of each student should be assessed and recorded after each activity by the course in-charge.

   3) Interactive Analysis & Design Tutorial(s) should be conducted, for application courses. The tutorial should be carried out by course-expert (preferably an industrial expert of the field). This would cover OBE system requirement for; solving complex engineering problem. Student’s performance shall be assessed, graded and recorded by the anchor person of the Tutorial.

• Remark: Above two activities (in 2 and 3) are Learning-cum-Assessment activities, therefore the students should be timely shared with the assessed scripts, corrected reports, and the teacher’s solutions.

   4) On conclusion of the semester, Examination Department of the degree awarding authority institution will administer MCQ type End Test, which will be based on very basic concepts of entire course, (covering all the CLOs). The test shall be carried-out on; unmanned or auto-assessment testing system.

   5) For qualifying the End Test, a well-defined yet moderate grading scheme needs to be introduced. For instance, candidates secured less than 50% marks in the Test, shall straight away be graded F (Fail), and they will have to repeat the course.

   Figure 3: Block diagram Illustration of Overall Proposed Solution
Grades, for the End Test finalists, shall be assigned by the Examination Authority, which shall be based on the student’s assessments at various Bloom’s Taxonomy domains.

- **Remark:** As per OBE System requirement, the final Assessment and Grading should be CLO based. Successful completion of a course should be conditional for students to acquire a minimum achievement level in each of the CLOs of the course.

7) After announcement of the Final Results, the Course-in-charges shall prepare and submit the Course Reports to the HOD, who will combine them in semester-wise folders. Each folder will contain: relevant Course Reports and their referenced-summary prepared by the HOD, in the format of Annex-C of “Manual of Accreditation” of PEC (p. 52.) [20].

8) Subsequently the HOD will circulate these Folders amongst the selected Academic Mangers, such as; Non-Teaching Faculty Members (or the External Members) of BOS, and the University Dean (or, Principal/HOI) for their evaluation and Improvement advices or recommendations.

- **Remark-I:** In Academic Managers, only HOD can be a part of teaching-faculty. External BOS Members, and Dean (or Principal/HOI) must not be having any teaching responsibility in the related Department; otherwise they will not be eligible for the Evaluation-and-Control assignment.

- **Remark-II:** Eligible Dean (or Principal/HOI) is the Chief (or Master) Controller. Therefore, the recommendations made by him, shall be binding for all of his subordinates, which includes HOD and all members of Pedagogic System.

9) The teaching-faculty will prepare course-plans for next Semester as per improvement advices of the Academic Managers. The Plans will be timely communicated to students and HOD.

10) HOD will ensure implementation of the; Course Plans and Improvement Recommendations, by his constant supervisory-control of the performance of Pedagogic system’s sessional activity.

- **Remark:** By emplonyment of LMS, the HOD can monitor up-to-date progress of the sessional activity of each course on his computer screen.

This solution will provide a regulatory mechanism, which will guarantee the achievement of desired learning-outcomes by the engineering graduates. It will also help improve quality of education, and therefore, it will further strengthen the overall CQI mechanism that the HEIs are operating under Quality-Enhancement-Cell (QEC).

VI. CONCLUSION

In this paper, a study is carried out to investigate the right implementation problem of OBE system and finding its solution, which can ensure achievement of all benefits of the OBE system. Summarizing the study, following conclusions can be made:

OBE System is a new system for Pakistani engineering HEIs. In fact, most of our engineering institutions are still in transition phase of converting previously employed Syllabus and Curriculum based education system into the Outcome Based Education (OBE) system. In this transition period some of the old academic practices are still being observed in adaptation of the new system. As the two systems have altogether different basic-principles therefore some of these old practices cannot be used as-it-is in fruitful implementation of OBE system. After detailed analysis, it is highlighted that requirement of the new System must be clearly understood and must be fulfilled. QEC and OBE Cell should play an active role in this regard. It is pleaded that:

- CLOs of the courses must be judiciously specified. That is, definition of CLOs must be based on main knowledge areas of the course. QEC and OBE experts should train the Teaching Faculty, in this regard.
- The QEC and OBE Cell must also play their role in all august academic bodies (BOS, BOF, AC etc.) to change the old and faulty academic practices as per OBE system.

Implementation of OBE system by the currently practicing CQI mechanism, which is based on inaccurate Assessment, (resulting) faulty Evaluation and a loose Control, will not be fruitful. Therefore, to solve the imperfect OBE system implementation problem, it is proposed that:

- Usage of technological Teaching-Learning Aids and that of the Computing and IT tools is the need of hour. It can significantly enhance Pedagogic system’s performance efficiency and can ensure accurate and speedy Assessment.
- Students final Assessment in each course should be CLO based. Successful completion of a course should be conditional for students to acquire a minimum achievement level in each of the CLOs of the course.
- To fast track and regulate the Academic Activity, introduction of an internal-feedback-control loop (within OBE Framework) is inevitable. It will also enable improvement of overall Evaluation process and will improve effectiveness of CQI mechanism for achievement of OBE system’s objectives.

The solution proposed in this study modifies and corrects the non-OBE based academic practices, inherited from previously followed system, and thence, it resolves faulty implementation problem of the OBE system. Secondly, it introduces regulatory mechanism, which makes the Pedagogic system to obey rules and regulation of the OBE system, in its true spirit. And finally, it guarantees: attainment of all learning-outcomes by the engineering graduates, and makes them ready for playing their role in accomplishment of Program Educational Objectives (PEO) in their professional life.
Post Script

We would like to conclude the paper with a final request to PEC and HEC of redefining the minimum teaching faculty strength for undergraduate degree programs. OBE system effective implementation have imposed extra burden on teaching faculty, as compared to work load in formal education system. Therefore it is required that present minimum teaching faculty strength may please be enhanced, and also role of teaching/lab assistants should also be acknowledged by increasing their strength in the said standard.

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Authors Contributions

The paper is a brainchild of Ashab Mirza, which is based on his experience of introducing and administering the OBE System in 2018 at Institute of Industrial Electronics Engineering (IIEE) as Principal-IIEE. In his 34 years of professional services (1986-2020) to Industry-Academia (SUPARCO & IIEE), he has 31 years of engineering educational experience: that is, from 1989 to 1997, on part-time basis in different local engineering HEIs (including NED UET) and afterwards on regular basis at IIEE, PCSIR (1997-2020). On the basis of his exposure of standard and quality (local and international) engineering education, his experience of OBE system administration, and his interaction with different professionals of engineering education from different HEIs of the country, he conceived the idea of this paper. Finally, he came up with this paper, with the help of his able and expert co-author. Therefore, his main contribution to this study was the concept development, supervision, correspondence, supervision and methodology.

Saba Javed is an experienced faculty member of PAF KEIT (2011-to date). She also completed her PhD studies in Electrical Engineering from this Institution. Her main contribution in this paper was the project administration, and paper writing.

Conflict of Interest

There is no conflict of interest between all the authors.

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