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Ensuring Quality Education For Out-of-School-Children Using AI based ROFSET Framework

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ABSTRACT

It is estimated that there are over 300 million out-of-school children (OOSC) worldwide. The United Nations Sustainable Development Goal (UNSDG) 4 aims to significantly reduce this number by the year 2030. A tremendous amount of effort and resources are being directed by national and international organizations to meet the UN SDG 4. Unfortunately, in some countries, the donated money for the OOSC goes into setting up fake schools often referred to as ghost schools. A large amount of the donated money is also being spent on monitoring and evaluation (ME) as well as other checks and balances to ensure transparency and accountability. But, unfortunately, the ME methods and the accuracy of information obtained are highly questionable. When such doubt arises, the money donated to such causes is stopped. In this paper, we present a radically new approach to ensure equity, quality, and accountability in education using a new ROFSET Framework. The ROFSET Framework allows us to introduce for the first time automation and artificial intelligence techniques for ME of teaching and learning effectiveness. It is cost-effective, easily deployable, and scalable. It is believed that the ROFSET Framework will make a significant impact on achieving the UNSDG 4 by 2030.

1. Introduction

The United Nation Sustainable Development Goal (UNSDG) number 4 on education is truly ambitious which aims to provide education to over 300 million out-of-school-children (OOSC) worldwide by the year 2030. The goal is to provide quality education and not just education. UN member countries are aggressively working to meet their set targets. Various private and public organizations, non-governmental organizations (NGO), and charities have received a great deal of money from donors to provide education opportunities to these OOSC . However, it is not easy or straightforward to determine how much of the donated money provided to these not-for-profit organizations is actually being used to meet the required UNSDG targets for education. For example, there is no objective way of ensuring equity, quality, and accountability in education for OOSC.

The work described in this paper provides an artificial intelligence (AI) technology-based framework that can overcome the monitoring and evaluation (ME) challenges facing the UNSDG for education. The framework we describe here is called ROFSET (Real-time Objective Feedback System for Effective Teaching). The implementation of the ROFSET framework is easy to deploy, cost-effective, scalable, and data collection and analysis is in real-time. Before we go into the details of the ROFSET Framework let us look at some major issues hindering the achievement of the UNSDG 4.

Ghost Schools Plague in Poor Countries

Recently, 900 ghost schools and 15,000 teachers were discovered in Pakistan and the funding for these schools was immediately stopped. Similar results were found in Nigeria, India, Afghanistan, Bangladesh, etc. SIGAR report of 19 June 2015 calls into questions about $769 million spend in the education sector in Afghanistan and probes the reliability of the data that the US uses to oversee and fund education in the country. For example, an organization may claim to be providing education to the OOSC but it is very hard to verify the claims due to expenses and compromised personnel doing the ME at the local level.

Current Monitoring and Evaluation Methods

Unfortunately, the ME problem is not confined to the OOSC but is a general worldwide phenomenon in many education institutions both private and public. However, it is more prevalent in the poor and developing countries. These methods to oversee the education institutions rely on outdated ME techniques that are unsuited for today's requirements. Furthermore, the ME methods are costly, inaccurate, subjective, and intrusive.

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The following are some of the challenges facing the education regulatory bodies and issues that are huge obstacles to achieving the UNSDG 4 for the OOSC.

- **Intrusive methods**: One or more inspectors observe classes to evaluate teaching and learning effectiveness. This method is intrusive and changes the way a teacher may teach during the inspection time.
- **Expensive**: External inspectors are costly. Hence, the frequency of their observations is usually once or twice a year.
- **Student feedback**: Student feedback is usually not accurate and is highly biased. A strict but an effective teacher may receive poor evaluation perhaps because he/she is giving too much work, strict on attendance, etc.
- **Developing course portfolios is time consuming**: An enormous amount of time is required to develop a course portfolio. It is usually prepared under a lot of pressure and it is most likely inaccurate.
- **Subjective**: Data and information gathered by the inspectors are subjective.
- **Mundane tasks**: Instructors are required to map, track, and analyze all learning outcomes.
- **Cumbersome**: Analysis of learning outcome is complex and requires a great deal of teachers' time and effort, and it is mostly inaccurate.

2.The ROFSET Framework

There are no methods currently available for accurately measuring teaching and learning effectiveness; tracking learning outcomes; use of education technologies; effective pedagogies used, etc. To obtain accurate data on teaching and learning, an innovative solution is needed.

Technology alone cannot solve the present ME problem without having some sort of intelligent agent continuously performing ME. In this paper, for the first time, we propose a new type of quality assurance framework called ROFSET. The ROFSET Framework (see Figure 1) has some unique built-in characteristic features including:

a. Real-time: Teaching and learning data capturing is done in real-time.
b. Non-intrusive: It does not interfere with the teaching.
c. Objective analysis: It is a machine-based system and, thus, it is not subjective.
d. Automated: Data capture and analysis of teaching and learning is done automatically.
e. Artificial intelligence (AI) engine: All inferences on data is done by algorithms embedded in the ROFSET Framework. The AI Engine generates reports and provides feedback to teachers on all Teaching and Learning Key Performance Indicators (TL-KPI).

To test the ROFSET Framework a pilot application was developed in the form of a presentation application and we called it PowerTeach (PT). PT is a thin client that can be used to teach any course in the same way that we use Microsoft PowerPoint (PPT). The difference between the two is that PowerTeach has an intelligence engine in the background continuously gathering data and analysing data of all the TL-KPIs in real-time.

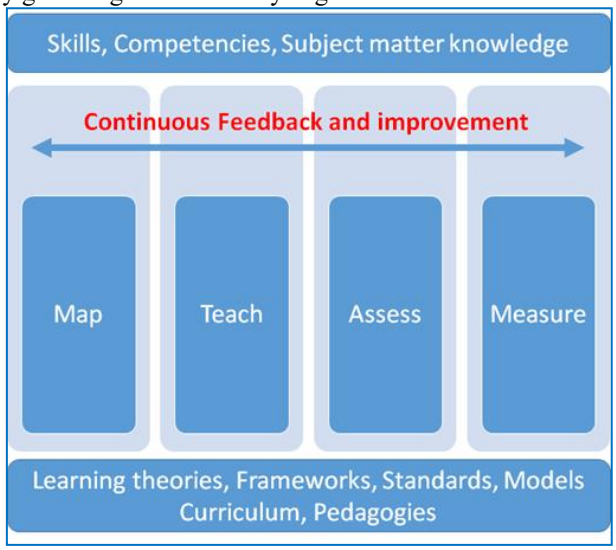


Figure 1. The ROFSET Framework

Automation of ME Using the ROFSET Framework

In general, automation has been very beneficial. Automation is everywhere, automation has given rise to the industrial revolution, printing press, mass production, and automatic speed cameras on highways. Everywhere we look we see automation. By default, automation is cost-effective, provides standardized products and services, and allows machines to be operational 24 × 7 without much human supervision.

With this in mind, we have developed the ROFSET Framework to fully automate the entire ME process in order to ensure equity, quality, and accountability in education for children. As we will see automation (or machine-

based ME system) will be the key aspect which will pave the way to overcome the UNSDG 4 issues discussed earlier.

Content Mapping in the ROFSET Framework

The material or the content taught to the students in a class by a teacher is based on a prescribed syllabus/curriculum. The syllabus/curriculum is usually designed by subject matter experts (SME).

To distinguish between the traditional course content/material and that used in the ROFSET we describe the traditional teaching material as 'passive' in the sense it is unable to respond to the teacher's interaction with it.

In the ROFSET Framework, we transform the passive traditional teaching material into what we call 'active content'. This is done by tagging and defining the response of the content when the teacher interacts with it. Not all the material is active. The active components are referred to as active objects and they all have specific data and functions associated with them.

The process of tagging is done by SME during the compiling of the teaching material or it can also be done by a qualified teacher. The process does not take long and only has to be done once not every time the material is taught unless of course there is a major change in the syllabus/curriculum. Hence, it is very efficient and effective. This one-to-many mapping is shown in Figure 2.

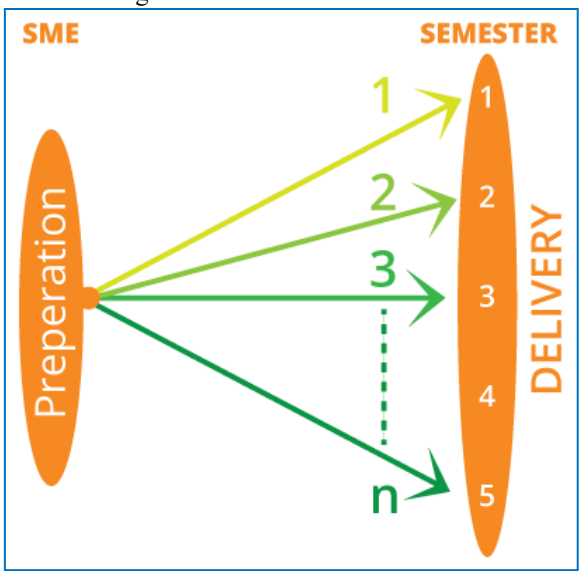


Figure 2. Content preparation and mapping

The active objects are able to receive and pass on information continuously to the AI engine in the ROFSET Framework. All this is happening during the actual teaching. This interaction data is analyzed by an AI algorithm that correlates content with the TL-KPIs to generate reports like the ones shown in Figures 4–6. The AI interface is seamless and is completely non-intrusive to the teacher and students. The ability of the ROFSET Framework to make the teaching content active is crucial to achieving equity, quality, and accountability in education for children.

Measuring Teaching Effectiveness Using the ROFSET Framework

We begin by defining what we mean by quality education. Quality education can be defined as teaching and learning according to a set of education standards typically encapsulated in the country's National Qualification Framework (NQF). Most countries follow the outcomes-based education (OBE) model. Each course has a number of learning outcomes (LO) that must be learned by students upon completion. The process of managing and ensuring that the LOs are properly covered during teaching is a relatively hard task.

For teacher evaluation, we often rely on student feedback, exam results, peer reviews, and class observations. These are all subjective methods. The problem of having these checks and balances for schools in areas with a high number of OOSC is even more troublesome because most of these areas are remote. Sending observers and inspectors to evaluate the teaching is very costly and often not practical. Relying on local personnel often gives rise to compromised results. In order to overcome these issues, we have defined several important TL-KPIs which can be tracked and measured automatically. Table 1 gives a summary of five TL-KPIs that can be used as a measure of quality education.

In this paper, we will present our findings for three TL-KPIs, namely course coverage, learning outcome coverage, and student participation. We have selected these because they provide the three key results we need for this work namely equity, quality, and accountability. Please note that the Measures column in Table 1 is a weighted component of the overall effectiveness of teaching and learning. It does not by itself account for the overall quality, accountability, or equity of education. The total number of TL-KPIs that we have identified in this work that can be used collectively to determine the overall effectiveness is 20 and is the subject of another article. In the ROFSET Framework, the overall effectiveness of a teacher is the weighted sum of all of the TL-KPIs.

Table 1. KPIs covered in the ROFSET Framework

TL-KPI	Description	Measures
Course coverage	How much of the course content was covered based on the prescribed syllabus requirement?	Accountability: The teacher has actually covered the course according to the syllabus as expected.
Topic depth (time dependent)	Have the relevant topics been adequately covered as required in terms of time and depth?	Quality: This to a certain degree provides the quality of teaching. For example, it measures the relative time spent on easy and hard topics.
Learning outcomes	To what extent the learning outcomes have been covered?	Quality: How many LOs have been covered. How much time was spent covering them?
Pedagogy	What methods were used to teach the various topics?	Quality: What methods and techniques were used in teaching?
Student participation	How well the students participated and were engaged in learning?	Equity: Comparative analysis between genders.

Quality Assurance and Control under the ROFSET Framework

Once the ROFSET Framework is used the feedback and reporting on all the TL-KPIs are available on any smart de3vice anywhere and anytime. The ROFSET Framework is a cloud-based, distributed architecture as illustrated in Figure 3.

If there is any deviation from the expected teaching and learning processes predefined alerts are sent to the monitoring agency or to the responsible person in charge of the ME. The ROFSET Framework provides full analytics on all aspect of teaching and learning to ensure the UNSDG 4 targets are being met.



Figure 3. All smart devices can be used for monitoring

3.Results

In this paper, we describe the results of measuring the five TL-KPIs of Table 1. The data was gathered from two schools in the UK. The data was collected manually to test ROFSET Framework. In this work, we have not taken into consideration the Hawthorne effect which states that the behavior of an individual changes when being observed analogous to the observer's effect in physics.

The results are provided in the form of graphs for better visualization and interpretation. We have not used all the 20 TL-KPIs as described in the ROFSET Framework. We selected those that are more relevant for the OOSC in terms of availability of resources. For example, we have left out TL-KPIs such as video and audio capture, access to learning management systems (LMS) such as Blackboard, Moodle, etc. These TL-KPIS will play a less significant role for children.

Course Coverage KPI

Figure 4 shows the course coverage of three subjects namely chemistry, physics, and biology for Grade 10. We can see from the graph that the biology course had a coverage of 68%, followed by chemistry at about 53% and physics at 46%. The latter two would be of concern to the head of the department. In this particular case, this was discovered towards the end of the course and immediately red lights were flashing. Extra intensive classes were given to students in the last two months to cover the missing material. This placed lots of pressure on student and faculty.

Using the ROFSET Framework the course coverage problems were immediately identified and interventions were made. The result shows a significant improvement as can be seen in the second column for each subject in Figure 4.

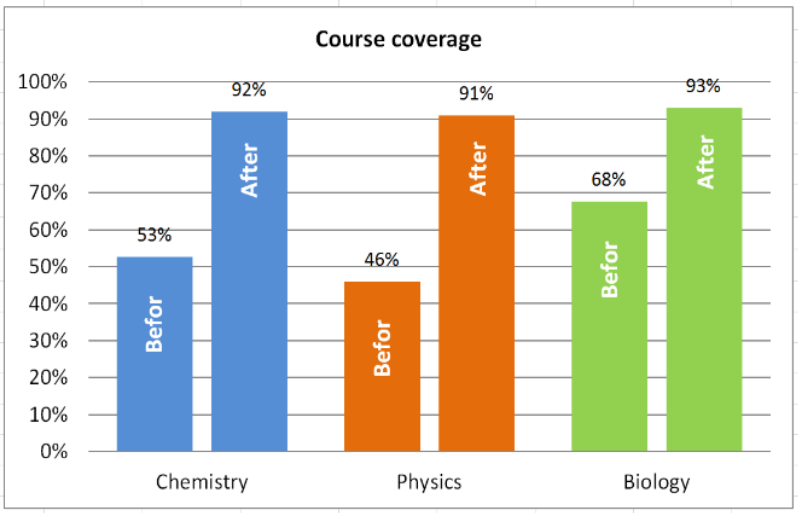


Figure 4. Results before and after using the software based on ROFSET

Learning Outcome Coverage KPI

Similar trends were seen in the LO for each of the subjects. That is using the ROFSET Framework there was considerable improvement in the coverage of the LOs and how well they were covered. Using the ROFSET Framework we calculated the LOs covered and correlated them with student achievements. The result is shown in Table 2.

We can see clearly that it is easy to obtain valuable insight into the teaching and student learning. For example, we can see that nearly the whole class found LO3 more difficult and hence performed less well in the exam. The ROFSET Framework allows us to drill deeper to determine the cause of this. It could be that LO3 was not covered thoroughly, or it was hard for this group of students, or the exam question was too hard or not designed well or the method of teaching was not effective.

Table 2. Coverage of LOs and their effectiveness

Student	LO1	LO2	LO3	LO4	LO5	Student Average
1	64	94	56	78	71	91
2	66	59	13	68	56	36
3	67	67	51	74	68	65
4	80	75	45	69	76	69
5	87	64	32	81	74	68
6	68	56	41	83	68	63
7	98	91	52	78	79	96
8	75	63	24	86	86	67
9	76	58	20	65	74	48
10	89	88	66	89	72	97
Class Average	77	67	39	79	72	67

Using such analysis, it is easy to pinpoint such cause and effect. We will describe this in another paper.

Similarly, we can see certain students were performing poorly in various LOs. From the table, we can identify 2 students who have scored low in the LOs as shown in Table 3 below.

Table 3. Automatic identification of weak students

Student	LO1	LO2	LO3	LO4	LO5	Student Average
2	66	59	13	68	56	36
9	76	58	20	65	74	48

With this type of knowledge, it was possible to provide differentiated learning for these students. Special worksheets can be provided to these students to improve their performance in the weaker areas. Other teaching strategies can also be used including group work where the weak student may be grouped with higher ability students assuming peer learning may help. There we can see clearly that the ROFSET Framework allows the teacher to adopt various teaching strategies for every student and in every class.

We can also note that the 3 students shown in Table 4 have scored very high marks in the LOs and in particular LO2. These students can be given additional more advanced work to ensure they are not being held back by other students.

Table 4. High achieving students' identification

Student	LO1	LO2	LO3	LO4	LO5	Student Average
1	64	94	56	78	71	91
7	98	91	52	78	79	96
10	89	88	66	89	72	97

Student Participation KPI

It was found that, using the ROFSET Framework, it was possible to obtain better results by engaging students who are less participatory. Different teaching strategies can be used to address these particular students and keep their progress in check through the ROFSET Framework. All students are provided or prompted with an opportunity to participate in class discussion and activities.

Overall it was also possible to track and show the progress of students' participation from all the previous classes. It was found that this feedback prompted competitiveness amongst student to participate more. This positive engagement generally resulted in better student focus on their learning during the class.

Figure 5 shows the overall participation of the female and male students. This result is reflective of the country in this case the UK. It is expected that the results would be different in different countries. However, in the ROFSET Framework, the teacher will have the tool to normalize gender inequality when it arises. This feature of the ROFSET Framework is of particular importance in regions where there is gender discrimination. The ROFSET Framework will show actual results.

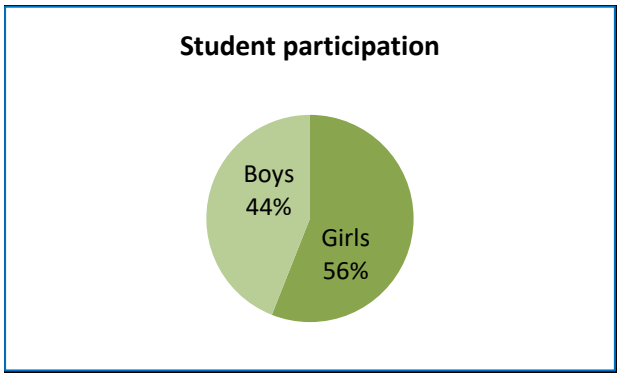


Figure 5. The male and female ratio for classroom participation

Teaching Effectiveness Using 3 TL-KPIs

Using data from the TL-KPIs it was possible to determine the teaching effectiveness of each teacher. It is important to know that the effectiveness in this case is defined as how close the teaching (actual) has been to the prescribed content (expected) set out by the SME. The result is the difference between the expected and the actual.

The teaching effectiveness is shown in Figure 6. We can see from Figure 6 that teachers 2, 5, 6, and 11 were performing well below expectations. This could have serious consequences on student learning progress. Later courses that rely on the knowledge of this course will also be compromised. If such cases go unchecked, it may lead to poor teaching standards and hence poor student performance.

It was mentioned earlier in this paper that when such cases are discovered it is often too late to rectify the problem with traditional ME. However, if time does permits, students are requested to attend extra classes which are very intensive with long hours. This places an extra burden on students and teachers. In the worst case scenario, such cases may go undiscovered and the students' ability to cope with later subjects that require prior knowledge also suffers. This situation does not arise when using the ROFSET Framework.

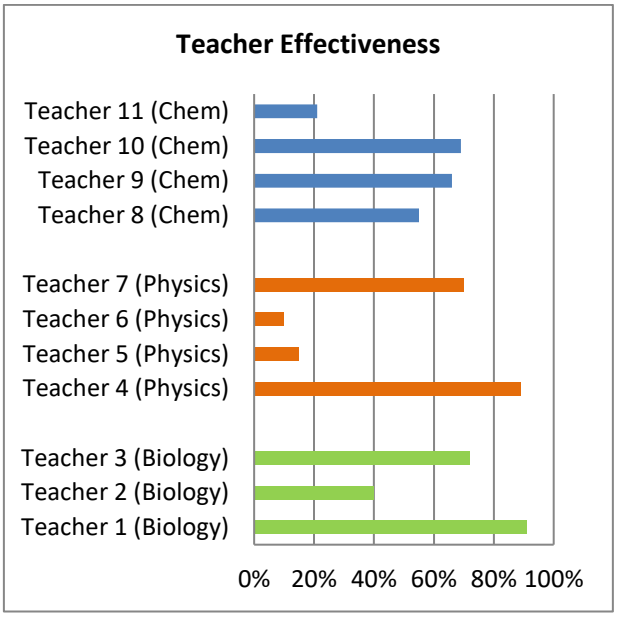


Figure 6. Teaching effectiveness comparison between different teachers

Teaching effectiveness improves dramatically when using the ROFSET Framework. The teachers were instructed on the use of the active content and it was found that all teachers met their expectation in teaching. Figure 7 shows the improvement in teaching effectiveness with the ROFSET Framework for teacher 2, 5, 6, and 11.

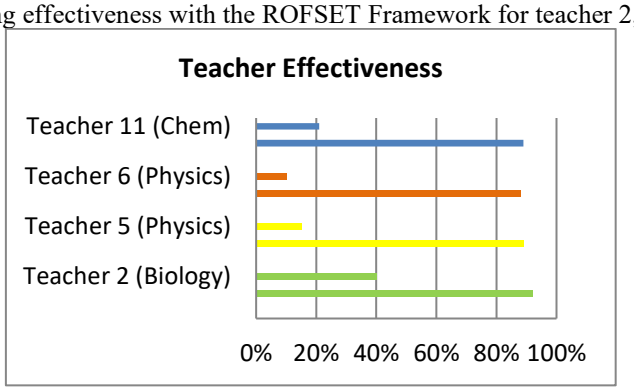


Figure 7. Improvement in teaching using the ROFSET Framework

The ability to provide real-time feedback to teachers is the key to this dramatic improvement. The ROFSET also provides just-in-time cues on how a particular section of the course may best be taught, e.g., group-based work, plenary, etc. These embedded features in the ROFSET free the teacher from remembering too much information. The teacher can self-evaluate and improve without any intervention. However, if there is no improvement and a threshold is reached it sets off an alert to the relevant individual or authority to intervene.

4.Discussion

A new education quality assurance framework called ROFSET was presented in this paper. The results obtained from using the ROFSET Framework showed significant improvement in teaching effectiveness and student learning. The two main reasons for such a dramatic improvement that can be seen immediately are due to two main factors.

1. Teachers know that a software version of the Hawthorne effect is seamlessly and invisibly working in the background during their lessons. The presentation application used for teaching, in this case, PowerTeach, is capturing all the TL-KPIs during the entire duration of the class. In other words, the ME of teaching and learning is being conducted by the ROFSET-based application.
2. The PowerTeach application is continuously providing the teacher with built-in cues or recommendations on how best to teach the material at hand as prescribed by the SME. Recommendations include using the best pedagogy, emphasis on LOs, student engagement and participation, group-based learning, etc. In this respect, the application acts as a useful guiding tool for the teacher.

It is worth noting that the teacher has the option of not following the recommendations made by the PowerTeach application (as prescribed by the SME) if they wish to do so. However, the data on their methods of teaching is still being collected and ME is being carried out as usual. The only time when ME will not be performed is when the teacher wishes to deactivate the ROFSET Framework from their application or use a different presentation application for their teaching. Opting out from the use of the ROFSET Framework would only happen with the proper authorization from the governing body. In the case of the OOSC not using the ROFSET Framework would be highly discouraged because of the issues identified earlier in this paper.

The ROFSET Framework is particularly useful for OOSC because the ME work can be assessed remotely using any smart device at any time. The ROFSET Framework also allows the entire ME process can be fully automated and to generate reports as and when required. This feedback is available to the teachers immediately for reflection and improvement. It is also worth noting that since the TL-KPIs are collected and analyzed in real-time, interventions can be made anytime in case the teaching and learning are not going as expected.
Some training is required for the teachers to be able to effectively use the various teaching tools available in the ROFSET Framework.

5.Conclusions

This paper presents a new approach for conducting ME to ensure equity, quality, and accountability for the UNSDG 4 on education. The new approach is based on the ROFSET Framework introduced. The ROFSET Framework uses automation, AI, and real-time ME on all aspects of teaching and learning during an actual class. The ME work in the ROFSET Framework is conducted non-intrusively, i.e., requiring no human intervention or special equipment, and, thus, it is extremely cost-effective and well suited for OOSC education.
Finally, it was demonstrated that the ROFSET Framework can lead to a dramatic improvement in teaching and learning effectiveness over a short time span.

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