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Perceptions of teachers towards the Use of Inquiry-Based Learning Following 5Es Instructional Model in Biology at Upper Secondary School Level in Rwanda

Henriette Manishimwe[1], William Aino Shivoga[2] & Venuste Nsengimana[3]

Abstract

The study examined perceptions of teachers towards the use of inquiry-based learning (IBL) following 5Es instructional model in teaching biology at upper secondary school level in Rwanda. It also examined the challenges faced by teachers while using the IBL instructional model. Six senior four secondary schools and having boys and girls students offering MCB (Mathematics, Chemistry and Biology) combinations were purposively sampled for the study which involved 6 teachers and 228 students, 109 in the control group and 119 in the experimental group. Though the qualitative research approach following phenomenological design with in-depth interviews was largely employed, quantitative data on students' achievement in, and attitude to learning, biology were also collected prior to and after the IBL implementation. Findings revealed that teachers perceive the IBL as a useful approach in teaching and learning biology as it assists to implement learner-centered method. Additionally, it polishes students' understanding of biological concepts, and hence promotes achievement. Further, teachers confirm that students' interest in biology and positive attitude change were observed upon using the inquiry instructions, and the skills to transfer their knowledge in real life situation were acquired, Furthermore, confirm that the IBL approach has raised students' interest to follow biology subject and positively change their attitude towards biology. Insights on 5Es instructional model were considered. However, time constraint, lack of teaching resources and need for classroom management were raised as challenges to successfully teach biology using the IBL. The study recommends the use of IBL following 5Es instructional model in teaching and learning biology upon having enough trainings for in-service teachers, and availability of teaching resources.

Keywords inquiry-based learning; perceptions of teachers; phenomenology design; 5Es instructional model

Introduction

Now science education stresses the use of active learning contemplating the participation of students in their knowledge construction as a core part of the learning process. In this regard, the Inquiry-based learning (IBL) is being extensively recommended for science classrooms and some educators have started to implement this recommendation (Mugabo & Nsengimana, 2020; Chikaluma et al., 2022).Throughout the IBL instruction, favourable self – learning oportunities are catered upon guidance of teachers. Resources are provided and activities to stirup students' thinking skills are provided. In this vein, students are responsible to build their knowledge and teachers

[1]Henriette Manishimwe, African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS), University of Rwanda College of Education (URCE), Rwamagana. Email: mahenrie03@gmail.com; ORCID: https://orcid.org/0000-0002-5797-2631

[2]William Aino Shivoga, Department of Biological Sciences, School of Natural Sciences, Masinde Muliro University of Science and Technology (MMUST, Kakamega, Kenya. Email: shivoga@gmail.com. ORCID: https://orcid.org/0000-0002-1694-9339

[3]Venuste Nsengimana, School of Science Education, University of Rwanda College of Education (URCE), Rwamagana, Rwanda. Email: venusteok@gmail.com. ORCID: https://orcid.org/0000-0001-5963-8314

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facilitate the learning process . In this perspective, the inquiry instructions grounded in constructivism theory allow learners to build their knowledge and evaluate their learning grasp (Voon et al., 2020).

Extensive studies have disclosed the learning outcomes supplied by the IBL, including upgrading understanding of biology concepts and achievements (Nunaki et al., 2019 ; Nisa, 2018;Erbas & Yenmez, 2011). The IBL also boosts interest in learning biology and attitude towards biology. Additionally, the activities given in learning process trace a favourable opportunity for the learners to develop thinking skills including critical thinking, problem solving and creativity (Rodríguez et al., 2019). Under the IBL students gather ideas from the observations, figure out solutions to the activity given by the teacher and use evidence to explain scientific phenomena. In this way, scientific thinking skills are built, and enthusiastic feelings are raised (Sandika & Fitrihidajati, 2018).

Within the IBL, 5Es instructional model was endorsed to establish a learning process under a sequence of five stages namely Engage, Explore, Explain, Elaborate and Evaluate which are interrelated (Bybee et al., 2006; Nkurikiyimana et al., 2022). In the Engage phase, teacher try to excite learners, usher them to discover the lesson to be taught and students with the teacher formulate the key question. In Explore phase an activity is given to students and resources and the knowledge is acquired through manipulating discussion and interpretation of findings. In the Explain phase students present the findings, concepts are clarified together with the teacher to remove misconceptions, and students' views are considered. In the Elaborate phase, the knowledge obtained is expanded into real life situation. Finally, the knowledge and skills acquired are evaluated in Evaluate phase. In all phases both students and teacher are involved and teacher nurture the learning process (Manishimwe et al., 2023; Nyirahagenimana et al., 2022; Duran & Duran., 2004; Ihejiamaizu et al., 2018).

Apart from the benefits of the IBL, some challenges were manifested in teaching and learning science subjects. These include time constraint which has been claimed by teachers, indicating that the inquiry methods are time consuming. The content is overloaded and not matching to the time allocated. Therefore, it is difficult to cover the content within the available time. Further, the problems related with teaching resources that are not enough has been raised in different studies (Enugu, 2016; Mugabo & Nsengimana, 2020). In relation with 5Es instructional model, challenges were demonstrated by different educators. Some indicated that while implementing the learning model, the content goes beyond planned time and classroom management is hardly controlled (Polgampala et al,. 2016). As result, the level of implementing the IBL following 5Es instructional model remains at a low level, hence professional development is needed to overcome challenges affecting the use of IBL and the 5Es instructional model (Mohamed et al., 2016).

Further, numerous studies illustrated the use and benefits of the IBL in teaching and learning science including biology (Manishimwe et al., 2022;Gormally et al., 2009;Ansari, 2019;Aktamiş et al., 2016). Few researches made a focus on the perceptions of teachers on its use in biology teaching, and the insight about the phases of 5Es instructional model is less highlighted. In addition, qualitative research with in-depth interviews on ways teachers perceive the inquiry instruction while teaching and learning biology are scarce. Since teachers play a

pivotal role in learning and in lesson delivery, their experiences and opinions might bring a tremendous support to improve the inquiry instructional methods. In this perspective, this study aimed to examine perceptions of teachers towards the use of IBL following 5Es instructional model in biology at upper secondary school level in Rwanda.

The present study responded to the following research questions:

1. How does the IBL play the role in improving students' learning outcomes?
2. What are the benefits of using the IBL/5Es instructional model in teaching biology?
3. What are the challenges faced by teachers while using the IBL/5Es instructional model in teaching biology?

Methodology

Research Design

In this research, phenomenology research design was adopted, seeking to know people's perspectives and opinions of respondents about a particular situation (Larkin et al., 2019; Dahlin et al., 2012). The design is strongly associated with interpretivism paradigm which seek to know experiences of participants with less prediction. It operates in cooperative and interactive setting between researcher and respondents and focus on specific and unique insights. It is socially established and allows subjectivity of people's opinions and experiences (Alharahsheh & Pius, 2020). Though data collection largely involved in-depth interview with biology teachers trained on the use of the IBL, it also involved the collection of quantitative data on their students' achievement in, and attitude to learning, biology prior to and after the IBL treatment.

Sampling Procedure

The study took place in Kigali city specifically in Kicukiro District and Southern province specifically in Kamonyi and Muhanga Districts, in Rwanda. Purposive sampling method was adopted, looking for schools having adequate teaching materials, having MCB (Mathematics, Chemistry and Biology) combinations at senior four secondary school and having boys and girls students. Two schools were identified in each district, totalling six schools. In each district one school was assigned as control group and another one was assigned an experimental group randomly. All the schools were at the same level as teaching and learning materials as concerned to trace the comparison.

In experimental group, students were subjected to the IBL approach using the 5Es instructional model, after providing a training to teachers about the inquiry instructional strategies, 5Es instructional model and their use while teaching and learning in science, biology in this regard. Three teachers of experimental group from three districts made the sample of the study. Studies affirmed that sample of qualitative research can be taken at low number, for the fact that data provided from participants are rooted in personal experiences, views are unique to the phenomenon (Mthuli et al., 2022;Curtin & Fossey, 2007). Teachers of control group, three in number from three districts used their usual ways of teaching and were not concerned by the training about the IBL and 5Es. In all, 228 students, 109 in the control group and 119 in the experimental group, participated in the study.

Instruments

The research instrument used in the study consists of fourteen semi-structured interview questions (see Box 1). Before data collection, the interview schedule was subjected to experts in science education at University of Rwanda, College of Education (UR-CE) for

Box 1 Questions in Teacher's Interview Schedule	
1.	What do you think about the role of IBL in helping students to gain knowledge required in biology?
2.	What is the role of IBL in enhancing learners' critical thinking in biology?
3.	Tell me about problem solving skills in Inquiry-based instruction?
4.	What do you think about the role of IBL in motivating learners to work collaboratively?
5.	How has IBL helped students to understand biology concepts?
6.	Which stage of the5Es instructional model has helped students to gain knowledge in biology?
7.	Which stage of the 5Es instructional model needs to be emphasized in order to provide meaningful learning?
8.	What do you think about the role of IBL in improving students' achievement in biology?
9.	What is the role of IBL in helping students to develop interest in biology?
10.	How has IBL contributed to enhance classroom interactions?
11.	Tell me about the contribution of IBL on students' attitude change towards biology?
12.	What do you think as benefits of using IBL in teaching biology?
13.	Could you please tell me about the challenges you faced while using IBL?
14.	What are new teaching strategies you have adopted while using IBL in teaching biology?

trustworthiness. Researcher triangulation was employed, in which two skilled researchers were involved in preparing interview schedule and making themes to requite one researcher's bias. In this regard, credibility was established (Curtin & Fossey, 2007) . Some grammar errors were identified and corrected, and finally the whole instrument for data collection was maintained. For the sake of data accuracy and fairness two other researchers in science education were involved in data analysis to check the way data analysed comply with participants' experiences and perspectives.

To ascertain dependability of the instrument, research assistant was noting down responses from participants and checking depart of the conversation. Flexibility and collaboration between researcher and participants were adopted to allow the interview to take place in natural setting and allow to get personal views and experiences to be revealed and not influencing participants' responses. In this vein, confirmability was ensured for the authenticity of this study.

Data collection procedures

Prior to data collection, research clearance letter was offered by University of Rwanda College of Education (UR-CE). In respective districts, permission to conduct the study was requested and provided. Participants were explained the purpose of the study and agreed to willingly participate in the research, thereby signing a consent form. The study was conducted from April to June of 2021. Within the study, there were teachers of control group who were briefed about the motive of the research and continue to use their habitual teaching method which is conventional teaching method characterized by more involvement of teacher and less participation of students. There were also teachers of

experimental group who were trained on the IBL and the use of 5Es instructional model.

Students from both control and experimental groups were taught by their respective teachers. They went through pre-test before learning the biology content to trace the baseline of their capacity. In the wake of intervention of four weeks, they passed a pot-test to check the impact of intervention. Then after, perceptions of teachers towards the use of the IBL following 5Es instructional model were examined. Teachers of experimental group, one from each district, were subjected to in depth interviews about their experience and perceptions of IBL in teaching and learning biology.

Data analysis

Dialogues with respondents were recorded and transcribed in a word document. Transcripts were organized and cleaned. Within data, kindred words appearing frequently were labelled. Upon recurrent reading, framework was spotted. Later, data were sorted into a framework and coded. Furthermore, a coding plan was pointed out across exploratory way ushered by data. Thematic analysis was employed, whereby data were examined by means of interpretative and categorization, while the inductive reasoning was adopted using unfold framework to group data and relationships judged. Responses were categorized and recurrent themes recognized as (1) the role of IBL in promoting understanding of biology concepts and performance, (2) the role of the IBL in enhancing students' thinking skills, (3) IBL increases in interest and attitude change towards biology, (4) Specific 5Es instructional model insights, and (5) challenges of using the IBL in teaching and learning biology. Referring, to pre and post-tests of achievement data, scores were calculated using Excel 16 and SPSS V.23. Data from Biology Attitude Questionnaire (BAQ) were analysed descriptively.

Results

Results are presented following categories and recurrent themes found during data analysis.

The role of the IBL in promoting understanding of biology concepts and achievement

Teachers revealed that the IBL is a good teaching approach where students are engaged in the lesson from the beginning to the end. Moreover, students are at the centre of learning grasping knowledge by themselves, and abstract concepts become tangible to them which improve their understanding of biology concepts, hence they achievement increases. One teacher portrayed that *"the IBL approach was new to me and was useful. I appreciated it more. When comparing this class and their elder in senior 5 and senior 6, I can see that their performance was high and they were motivated to answer. I can't hesitate to say that the IBL s helped me to change the way of teaching and hence my students got enough knowledge* "*Additionally, my way of teaching by using the IBL Helped students to understand biology concepts so that at the end of the lesson many questions were asked. It was my first time to see students asking question after the lesson, even after working hours. They have developed a habit of doing research after the end of the lesson and come to ask me questions when they face a challenge".*

Further, with the IBL, students retain more and could not forget easily what they have explored. When it comes to assessment their achievement improved. Another teacher was able to witness this." *There is other capacity that students gain through the IBL.The explore phase helps them to search and gain more knowledge and they retain what they have themselves found during the group work. When it comes to assessment, they cannot forget what they have explored, hence they perform well in the assessment. Compared with the time I was teaching without involving students, there are point I could not touch. However, through the use of the IBL, students ask questions and the*

content is fully covered as it is planned, then students get more, master the concept, and their achievement improves.

The statement was supported by the results obtained by students in pre- and post- test. It was clear that students subjected to IBL outperformed their counterparts in terms of performance and attitude change in biology. Findings of descriptive statistics revealed that students were the same in terms of achievement before intervention (see Table 1). Results of post-test indicated a larger mean gain for experimental group greater than the control group implying that the IBL improves students' achievement in biology.

Table 1 Students' pre and post-test marks

Group	N	Pre- test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Experimental/5Es	118	47.43	8.40	73.61	10.652	26.18
Control/CTM	119	47.18	9.5	60.12	11.171	12.94

Concerning attitude to learning biology data collected prior to and after the IBL treatment, descriptive statistics of mean and standard deviation were computed for all attitude factors or attitude subscales namely, interest, easiness, importance and career (see Table 2). All groups, female and male students scored almost the same mean (3.7, N = 5) before learning except at easiness factor where all groups consider biology to be difficult. Upon intervention, there was attitude change in all dimensions revealing the impact of intervention in all groups. Findings portrayed that the inquiry instruction helped students to improve their interest more from when compared to control groups. The same to importance and career factors, experimental group outperformed the control group. Coming to easiness factor, after learning the IBL alleviated the difficulty of the biology subject and find it easy to learn compared to their counterparts. For instance, on the side of experimental group means scored improved from 3.31 to 4.35, while the mean scores of their counterparts increased from 3.25 to 3.59. To this end, the IBL has helped students to improve their attitude towards biology, due to

Table 2 Descriptive statistics of the attitude sub-scales

			Pre-test		Post-test	
Factors	**Group**	***N***	***M***	***SD***	***M***	***SD***
Interest	Control	109	3.77	0.3	4.24	0.5
	Experimental	119	3.78	0.31	4.5	0.26
Easiness	Control	109	3.25	0.6	3.59	0.71
	Experimental	119	3.31	0.64	4.37	0.32
Importance	Control	109	3.84	0.32	4.3	0.46
	Experimental	119	3.84	0.45	4.5	0.27
Career	Control	109	3.81	0.59	4.49	0.63
	Experimental	119	3.89	0.7	4.67	0.36

their conducive learning environment it creates.

The role of the IBL in enhancing students' thinking skills

Teachers reported that the IBL gives an opportunity to learners to develop higher order critical thinking and problem-solving skills. They have highlighted that during the explore phase, students were able to work on the activities, gathering information from different learning sources and testing facts with scientific evidence. To add on that they were able to transfer their knowledge in real life situation. This has been highlighted by one teacher who said that:" *The biology lesson of today was about microbiology. The topic was purely experimental. Even though we did not get much time to carry out many experiments, students would proceed with simple experiment and ask more questions about microorganisms that they actually can't see with naked eyes. Further, they could successfully work on the activities related to daily life in the Elaborate phase. I do confirm without hesitating that their problem-solving skills were enhanced using IBL/Es instructional model teaching approach".*

The IBL increases interest and attitude change towards biology

It was observed that IBL increases students' interest in biology by virtue of letting them learning in social context. In this regard, slow learners were able to participate actively and share their ideas, which was not the case in normal teaching. With hands-on activities, everyone was engaged in learning process and was able to extend the knowledge and skills and relate the content with the real life. Further, the attitude towards biology changed based on how they asked questions about what they can do in real life to generate an income based in the studied lesson. One teacher ascertained that," *The IBL method promotes the knowledge transfer in real life and helps students to become more interested in in biology. For instance, during microbiology lesson, they get to know how they can prevent infectious diseases and how to make bread. The IBL increased curiosity and interest to follow and enjoy biology lessons.* Opportunities were provided to learn in groups and students interacted more, the stronger ones helped the slow learners. As result, there was an increase in the interest to learning biology. This was confirmed by another teacher who replied that "the *method helps students to collaborate, for example if someone didn't understand the concept can consult other group members and get a help to better understand the content easily. This method is good for group working".*

Specific 5Es instructional model insights

In this study, the IBL was designed by 5Es instructional model which is a learning cycle having a sequence of phases that are interdependent: engage, explore, explain, elaborate, and evaluate. Teachers were able to identify the explore phase as a stage by which students gain more knowledge and skills as one of them indicated," *The second phase of the 5Es, namely explore helped students to get more knowledge in biology. I used to think that students have to be taught how to do things and this explore phase changed to how students can do things. I have seen that they know many things which I could not expect before. It was the pillar in exploring living world".*

Furthermore, teachers have asserted that some phases of 5Es instructional model need to be emphasized for the meaningful learning. One replied that" *The elaborate phase needs to be emphasized to provide meaningful learning as it extends the knowledge to a new situation in real life. In this context it helps learners to love biology as they see its importance and application."*

Briefly, teachers perceived IBL/5Es instructional model as a useful teaching approach that helped them to enable the

participation of learners in the lesson from the beginning to the end. Students were able to work hand in hand with the teachers and build the knowledge. None of them could get tired or bored as it used to be the case. One teacher said that: *the knowledge acquired through the* IBL/5ES *cannot be forgotten. Students were able to transfer new knowledge and skills in real life. For instance, in practical experiment, they were able to make their own products like bread, and yogurt. Through the* IBL/5Es *student could learn by themselves, and this promotes self-directed learning which motivated them to become more interested in the lesson ".* Another benefit of the IBL/5Es is to give an opportunity for assessments, where during the evaluate phase, the learning process evaluated following different levels from remembering to the evaluation of the situation and creation of new products. This was witnessed by one teacher:" *Through the IBL/5Es, I have learned how to evaluate my students during teaching and learning process. Formative assessment is more practicable and successful than before ".*

Challenges of using the IBL in teaching and learning biology

Even though the IBL/5Es instructional model was successful in teaching and learning biology, challenges associated with it have been reported by some teachers. These include mainly time constraint. Most of teachers affirmed," *The challenges I have encountered in this method is time consuming. You cannot approach each group and even individual and finish the program. This method reduces the speed to cover the full content planned in the curriculum. "*Another challenge is classroom management, where disruptive behaviors may arise if attention is not taken in advance. Hence, the learning process may not take place appropriately. Further, enough learning resources must be availed and much as they are needed for the successful implementation of the IBL/5Es. In relation to this point, one teacher said that" *This method is time consuming; it is difficult to finish the subject content. Moreover, you cannot use this method without appropriate materials like ICT tools and charts. And classroom management must be controlled because some students may not fully participate in groups which may end in going home without gaining required knowledge and skills* ".

Discussion

The aim of this study was to examine perceptions of teachers towards the use of the IBL following 5Es instructional model in biology at upper secondary level of education in Rwanda. Findings revealed that the IBL help students to more understand biology concepts, and improve the level of achievement. This is associated with the learning environment offered by the IBL following 5Es instructional model, in which students are active at each stage of the learning cycle where, through learning in groups strong ones could help slow learners to go through the content easily. Further, hands-on activities were prevailed, and students grasp the concepts by themselves with teachers' guidance. This has promoted long-term learning and students could not forget what they have learned, hence their performance improves. This was affirmed by other studies which indicated that the IBL contributes to deep understanding of science subjects and promote students' achievement (Manishimwe et al., 2023; Jiun et al., 2018).

In the context of thinking skills, the IBL contributed to foster higher order thinking skills favouring critical thinking skills and promoting problem-solving skills. This could be delineated by the learning environment

provided by inquiry learning cycle, particularly at the explore phase, where students were probed with experiment or activity that they have to conduct, and share ideas about how to proceed and gather information in relation with the task given by the teacher, hence their problem-solving skills were enlarged. During the elaborate phase, a supplementary activity was given to students so as to transfer their knowledge and skills in real life, hence their critical thinking expand as pledged by Duran and Dökme (2016). Additionally, explore and elaborate phases of inquiry learning cycle were supported to be emphasized since during these stages students acquire more as learning outcomes as concerned.

Alongside interest and attitude learning outcomes, the IBL has contributed to the increase of interest in learning biology and improved attitude towards biology. This is linked with competences provided by the IBL to expand knowledge and skills to copy with everyday life and the learning in social context by which students interact much and help one another. For instance, students were able to know the application of microbiology in medical field and in food science. This has opened their mind and come to realize what they can do with biology in real life for example. This corroborates with another research which as indicated that students subjected to the IBL consider biology as a career lead subject and their interest and attitude towards biology is enhanced (Manishimwe et al, 2022 ;Sandika & Fitrihidajati, 2018).

Further, teachers reported the IBL to be helpful as effective teaching strategy to assist in implementation of learner-centered method following the fact that in Rwanda the curriculum has changed from knowledge-based to competence-based. Some teachers were struggling to involve learners in their learning process and help them to develop competences needed to copy with real life. The problem can be solved using the IBL which assisted teachers to involve learners in the learning process and helped them to acquire needed skills in real life like bread making and yogurt in this study. This is consistent with other studies which indicated that the IBL is more practicable for active participation of students in science classroom (Derting & Ebert, 2010; Mkimbili et al., 2017) .This could be explained by the fact that by following each phase of 5Es instructional model, learners were involved, and teachers played the role of facilitation.

Furthermore, the IBL was recognised as a teaching approach that facilitate educators to do the assessment in each learning process. This could be justified by the last stage of 5Es learning cycle of the IBL, in which teachers assess the learning outcomes of students. Within this stage students can make peer assessment. This is newly highlighted by this study showing that formative assessment can be applied in each lesson for diagnostic purpose, help teachers to evaluate the teaching strategies and to know how much learning was successful.

Besides the benefits of the IBL in teaching and learning biology, challenges were faced during its execution. Time constraint was highlighted by all teachers, saying that upon inquiry-based instruction it is difficult to cover the full content of the subject in allocated time. The teaching method is providing tremendous outcomes, but it is time consuming. This is in consonance with the findings of Kinyota, 2020 ;Mugabo and Nsengimana, 2020 who pointed out that teachers found the IBL time consuming in lesson preparation and teaching, which is not matching with time allocated to subject syllabus. The same authors have indicated also that teachers do not have enough skills to use IBL in their teaching. Lack of enough teaching resources was observed for proper use of IBL and without them, lesson will not be delivered fully as inquiry instruction as concerned. The same

scenario was highlighted in other studies (Akuma & Callaghan, 2019; Mugabo & Nsengimana, 2020). In addition, this study illustrates classroom management as a challenge within the IBL practices in teaching and learning biology as declared by Polgampala et al.(2016). Teachers need to manage their classes effectively to allow learning process to be appropriate, for students will be interacting much and disruptive behaviors may arise.

Conclusion and Recommendations

Substantially in this study teacher revealed the role played by the IBL to improve learning outcomes in biology, and challenges for its successful implementation. It was observed that inquiry-based instructional strategies offer a conducive environment for students to understand more biology concepts and improve their performance. Higher order thinking skills like critical thinking and problem-solving skills were more developed upon the IBL instruction. On top of that, students were given opportunities to interact with their peers and sharing ideas as well as use different resources to explore biology concepts by themselves. This raised their interest in biology, and students were able to know what they can do with biology in real life, hence their attitude towards biology changed positively. Teachers perceived the IBL to be useful in teaching and learning biology. However, the challenges like time constraint and needs for adequate teaching resources were identified for fortunate accomplishment. This study recommends the use of the IBL following 5Es instructional model in teaching and learning biology and provision of trainings to educators for effective use of the IBL/5Es instructional model. Additionally, further studies can investigate proposed solutions of teachers for successful implementation of IBL at upper secondary level.

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