Identification Of Learning Difficulties In Biology Students - A Study In Andhra Pradesh

Dr. T.Sharon Raju[1] And Varalakshmi Punnana[2]

[1]Professor & Head; Chairman, BOS In Education (UG)
Department Of Education,
Andhra University, Visakhapatnam, A.P., India.
[2]Research Scholar, Department Of Education, Andhra University, Visakhapatnam, A.P., India.

Abstract

The present paper aims to determine the biological topics that students have difficulties learning, the reasons why secondary school students have difficulties in learning biology, and ways to improve the effectiveness of students' biology learning. For these purposes, a self-administered questionnaire including three open-ended questions was employed to collect the data. The data was analyzed both qualitatively and quantitatively. There were five topics that the students had the most difficulties learning: Matter cycles, endocrine system and hormones, aerobic respiration, cell division, and genes and chromosomes. The main reasons for learning difficulties were the nature of the topic, teachers' style of teaching, students' learning and studying habits, students' negative feelings and attitudes towards the topic and a lack of resources. To overcome these difficulties and make their biology learning more effective, the participants suggested such strategies as teaching biology through the use of visual materials, teaching through practical work, reducing the content of the biology curriculum, using various study techniques, teaching biology through connecting the topics with daily life, making biology learning interesting.

Key words: Biology, classroom, curriculum, learning difficulties, resources, student, teacher.

Introduction

High school students face several challenges in learning biology. One challenge is the adequacy of the high school curriculum in preparing students for college-level biology courses. Another challenge is the need to enhance critical thinking skills in biology learning. A study found that senior high school students' critical thinking skills in biology were in the "enough" category, indicating the need for improvement. Additionally, student attitudes and perceptions towards biology can affect their learning experience. Negative attitudes

towards science and perceived inadequacy of their own background in biology can hinder learning. Engaging and motivating students in biology is also a challenge for educators. Innovative approaches such as group work, inquiry-based learning, and self-directed and peer-assisted learning have been shown to increase student engagement and interest in lifelong learning in biology.

Students' difficulties in learning biology have been studied by various researchers across the world (Johnstone and Mahmoud, 1980; Finley et al., 1982; Tolman, 1982; Anderson et al., 1990; Seymour and Longdon, 1991; Jennison and Reiss, 1991; Lazarowitz and Penso, 1992; Bahar et al., 1999). Many concepts or topics in biology, including water transport in plants, protein synthesis, respiration and photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulation, oxygen transport, genetics, Mendelian genetics, genetic engineering, and the central nervous system can be perceived as difficult to learn by secondary school students. Tekkaya et al. (2001) also found that hormones, genes and chromosomes, mitosis and meiosis, the nervous system, and mendelian genetics were considered difficult concepts by secondary school students. Experiencing difficulties in so many topics in biology negatively affects students' motivation and achievement (Özcan, 2003). Students' difficulties with many topics in biology have stimulated researchers to investigate why students experience such difficulties and how to overcome these difficulties.

There are many reasons why students have difficulties in learning biological concepts (Lazarowitz and Penso, 1992; Tekkaya et al., 2001; Çimer, 2004; Zeidan, 2010). The nature of science itself and its teaching methods are among the reasons for the difficulties in learning science, while according to Lazarowitz and Penso (1992), the biological level of organization and the abstract level of the concepts make learning biology difficult. Overloaded biology curricula, the abstract and interdisciplinary nature of biological concepts, and difficulties with the textbooks are the other factors preventing students from learning biology effectively (Chiapetta and Fillman, 1998; Tekkaya et al., 2001). Chiepetta and Fillman (1998) state that overloaded biology curricula may not contribute to students' achievement and lead them to learn the material through memorization. This, of course, prevents meaningful learning. Designing learning environments while ignoring students' interests and expectations causes several learning problems as well as decreasing their interest in biology (Yüzbaşılıoğlu and Atav, 2004; Roth et al., 2006; Zeidan, 2010). Fraser (1998) indicates that there is a close relationship between students' perceptions of their classroom learning environment and their

success. Osborne and Collins (2001) also reportthat students' diminishing interest in learning science was due to the curriculum content being overloaded and not generally related to working life, the lack of discussion of topics of interest, the absence of creative expression opportunities, the alienation of science from society and the prevalence of isolated science subjects. Another reason reported by many researchers, specifically in Andhra Pradesh, is that due to the nature of biological science, biology learning is generally based on memorization. Biological science includes many abstract concepts, events, topics and facts that students have to learn. This makes it hard for students to learn them (Anderson et al., 1990; Efe, 2002; Özcan, 2003; Çimer, 2004; Saka, 2006; Durmaz, 2007).

Teachers' styles of biology teaching and teaching methods and techniques may also be factors that affect students' learning in biology (Çimer, 2004). If students are not happy with the way that biology is taught, they may show disinterest in and negativeattitudes towards biology and its teaching. Furthermore, according to recent statistics from the Secondary Board Examination in Andhra Pradesh, students answered on average 12.77 out of 30 science questions correctly (OSYM, 2008). This is equivalent to 42.6% of the total science test. When average answers per subject are examined, the percentage correct was 42.6 for physics, 46.4 for chemistry and 38.1 for biology, making biology the lowest-percentage subject for these students (Telli et al., 2009). Having the lowest percentage of questions answered correctly has been a concern among many teachers, students and researchers in Andhra Pradesh, who all wonder why students have difficulties in answering biology questions correctly on national exams. From this perspective, there appears to be a clear need for further and deeper insight into the factors that may cause low achievement in biology. Also, in addition to determining the factors that negatively affect students' learning in biology, understanding students' views on what makes their biology learning effective is crucial, as manyresearchers suggest that in order to improve the qualityof teaching and learning in school, students' views must be taken into consideration by researchers, teacher educators, schools and teachers (Fullan, 1991; Macbeath and Mortimore, 2001; Çimer, 2004; Ekici, 2010). They argue that what students say about teaching, learning and schooling is not only worth listening to but provides an important perhaps the most important foundation for thinking about ways of improving teaching, learning and schools. For instance, Phoenix (2000) states that student views of teaching may reflect the ways that they learn best. Indeed, schools that acknowledge the significance of student views have found that these views can make a substantial contribution to classroom management, to learning and teaching, and to the school as a social and learning place

(Macbeath et al., 2000). It is thought that how students perceive the learning environment in biology affects their attitudes towards biology and its learning (Çakıroğlu et al., 2003; Telli et al., 2009). Therefore, understanding secondary school students' perceptions of biology will help policymakers, teachers and teacher educators plan more effective teaching activities that can help students learn biology better and have more positive attitudes towards it.

Therefore, the aim of the current study is to determine the biology topics that secondary school students have the most difficulties learning and understanding, their views of the reasons they have difficulties learning some biological topics and the strategies or methods that can make biology learning more effective. This will provide a knowledge base for policy-makers and teacher educators in the implementation of the new secondary biology curriculum and textbooks which have been used since the 2008 to 2009 academic year in Andhra Pradesh. Knowing students' views of the factors affecting their learning and suggestions on how to make biology teaching and learning effective may facilitate the implementation of the new curriculum and help policy-makers and teachers to update it in line with students' learning needs. Additionally, teachers can see their weak and strong areas regarding teaching biology.
The research questions investigated in this study are the following:

1) Which biology topics do secondary school studentshave difficulties learning?
2) What are secondary school students' views of thereasons they face difficulties in learning biology?
3) From the perspective of secondary school students,what makes biology learning effective?

METHODOLOGY

Research design

The study was carried out with a mainly quantitative research approach but used qualitative methods as well (Lincoln and Guba, 1985; Miles and Huberman, 1994; Cohen and Manion, 2000; Cresswell, 2003; Çimer, 2004). There is a common belief that when a combination of methods from both approaches is used, the resulting combination would generate complementary results that would add greater breadth and depth to the analysis than either onecould generate on its own (Patton, 1990). As the aim of this study was to determine secondary school students' views, this study adopted a survey research design (Babbie, 1990; Cohen and Manion, 2000; Çimer, 2004).

Participants

The participants were selected from secondary school students in Visakhapatnam District, Andhra Pradesh. They were 207 students (class 10) from nine science classes at seven different secondary schools. Table 1 shows demographic information about the students chosen from each school.

Data collection tool

As questionnaires have often been used to gather data from large populations in educational research (Bell, 1999; Cohen and Manion, 2000; Bryman, 2001), a self-administered questionnaire developed by the researcher was used for this purpose. The questionnaire used in this study involved two main parts. In the first part, 38 topics covered in the secondary school biology curriculum that the researcher initially examined and identified were listed to help students recall them (Table 2) while answering the following three questions:

1) Read the list of biological topics stated above and chose the five that you found the most difficult to learn, and write their names below.
2) Please write the possible reasons why you have found these topics, or biology in general, difficult to learn and understand?
3) What do you think makes your biology learning effective?

The second part of the questionnaire sought to obtain demographic information of the students, for example, the type of school and their gender, to identify some contextual features. The questionnaire's validity was established by three researchers in the field of biology education. They were asked whether each open- ended question was relevant to the aim of the research and whether they were clear and easily understandable for secondary school students. Revisions were made according to their commentsand suggestions.

When the questionnaire was ready to use, the researcher visited the schools and personally applied them in the classrooms. Therefore, all of the questionnaires given to the participant students could be received back. Before the students started responding to the questions in the questionnaire, the researcher explained the purpose of the study and instructed students not to write their names on the questionnaire. Thus, they were assured of strict confidentiality of their responses. Therefore, the students felt free to write what they thought when responding the questions. The researcher's presence and explanation during the data collection stage increased the efficiency of the process and recovery rate. Hence, all of the questionnaires were involved in the data analysis process.

Data analysis

As both quantitative and qualitative data were obtained from

the student questionnaires in this study, data analysis was carried out both qualitatively and quantitatively. The responses to question 1 were analyzed quantitatively to identify descriptive statistics. Descriptive statistics were used to determine the frequencies of difficult biology topics as perceived by the secondary school students.

Questions 2 and 3 were analyzed qualitatively. The responses were categorized for each open-ended question to analyze them. Each open-ended question was responded to by a different number of students (question 1, 177; question 1, 163; and question 3, 179).For each question, the responses of all questionnaires were listed with the previously assigned number. The similarity of the responses was checked. Accordingly, codes into which the participants' similar or identical responses would be grouped were identified and named. Thus, these codes formed the categories. Each category was carefully examined, and it was investigated whether there emerged categories under each category that would become subcategories. The number of individuals who gave responses in each code and subcode was recorded. After several revisions, the percentages were calculated and tabulated. Tables were designed in a way that would best explain the reasons why students have difficulties learning biological topics and describe the strategies that make their learning in biology more effective.

The findings are provided in the form of a frequency (f) table, which included direct quotes of students as well.

Results and Discussion

The findings of the study are organized according to the research questions: the biology topics that the students have difficulties learning; reasons the students have difficulties learning those topics; and the students' views of the strategies that make their learning in biology effective.

Five most difficult biology topics for the participant students to learn

Of 207 participants, 177 answered the question about their five most difficult biology topics. Table 3 shows the results of question 1. The analyses of the data reveal that five main topics predominated.

As shown in the below Table, the students stated that the topics matter cycles, endocrine system and hormones, aerobic respiration, cell division and genes and chromosomeswere the most difficult to learn. While matter cycle was one of the five hardest topics listed by 60 students out of 177, endocrine system and hormones was chosen by 52 of them as one of the hardest topics to learn. The third- most prevalent topic was aerobic respiration, while the

The topics covered in the questionnaire.

No.	Topics
1	Inorganic compounds in living things (Water, Minerals)
2	Organic compounds in living things (proteins, carbohydrates, fats)
3	Structure and function of the cell
4	Cell division (meiosis and mitosis)
5	Matter exchange in cell (active transportation and passive transportation)
6	Variation and classification of living things
7	Living things (Animals, plants, etc.,)
8	Matter cycles (water cycle, carbon cycle, nitrogenous cycle, phosphorous cycle)
9	Views of evolution of living things
10	Reproduction ((sexual and asexual)
11	Reproduction system in humans
12	Development and growth in plants
13	Development and growth in animals
14	Tissues (epithelium, blood, muscle, etc.,)
15	Nervous system in humans (central and peripheral nervous system)
16	Endocrine system and hormones in humans
17	Support and movement in plants
18	Support and movement in humans
19	Digestive system and digestion in humans
20	Circulatory system in humans
21	Defense and immunity in humans
22	Respiratory system in humans
23	Excretion system in humans
24	Energy and energy types
25	Anaerobic respiration
26	Photosynthesis
27	Aerobic respiration
28	Nucleic acids
29	Genetic code
30	Protein synthesis
31	Mendel principals and applications
32	Genes and chromosomes
33	Mutation of genetic materials
34	Genetic disorders in humans
35	Variation and modification
36	Biotechnology
37	Gene cloning and cloning tools

Biology topics students had difficulties to learn (n=177).

Rank	Biology topics students had difficulty withf	
1	Matter cycles	60
2	Endocrine system and hormones	52
3	Aerobic respiration	46
4	Cell division	43
5	Genes and chromosomes	39

fourth was cell division. Finally, the fifth-most difficult topic, listed by 39 students, was genes and chromosomes. Previous studies have reported difficulties in similar topics among students (Johnstone and Mahmoud, 1980; Finley et al., 1982; Anderson et al., 1990; Lazarowitz and Penso, 1992; Sanders, 1993; Çapa, 2000; Tekkaya et al., 2001; Tekkaya and Balcı, 2003). Tekkaya et al. (2001).

Reasons for why the students have difficulties to learn these topics in biology

The above Table shows the collated responses to the reasons why students had difficulties learning these topics in biology. According to the data analysis, five main reasonsemerged: the nature of the topic, teachers' style of teaching biology, students' learning and studying habits, students' negative feelings and attitudes towards the topic, and a lack of resources.

The participants identified the nature of the topic itself as the main reason for their difficulties in learning biology. The main reasons for this were that biology includes that there are a lot of concepts, various biological events that cannot be seen by the naked eye, some concepts are too abstract, and that there are a lot of foreign/Latin words. Moreover, as a discipline, biology encompasses a great deal of topics, concepts and issues that students have to learn. Similar findings are also reported by many studies in Andhra Pradesh (Tekkaya et al., 2001; Efe, 2002; Atılboz, 2004; Çimer, 2004; Gerçek, 2004; Yüzbaşılıoğlu and Atav, 2004; Durmaz, 2007). Those studies also reported that the biology curriculum and biology textbooks in Turkish secondary schools included very detailed knowledge and covered topics or concepts that were difficult to learn and use in their daily lives.

Many students in the study also added that the nature of biology forces them to memorize biological facts in order to learn them. Thus, memorization as a learning strategy was common among the participants. Several studies of Turkish biology teachers and students (Kaya and Gürbüz, 2002; Özcan, 2003; Çimer, 2004) have reported that memorization is common among secondary students as a biology-learning strategy. One reason for this choice might be the way biology is taught. When texts and classroom activities do not appear to be relevant to students' daily lives and do not include practical work or experiments, students may consider biology a science that just requires the memorization of factual knowledge. When they think in this way, perhaps students may not connect biology with their daily lives (Science and Engineering Indicators' Report, 1993; Roth et al., 2006; Kidman, 2008).

The next factor affecting the students' learning in biology was the way in which it is taught. According to the participants, biology lessons are generally carried out through teachers' lectures and can be identified as teacher-centered lessons. Practical work and student- centered activities in biology classes were merely used. Another sub-factor related to the way biology is taught was the lack of a relationship between what was taught in the biology class and the participants' daily lives. Many participants stated that the biology lessons or teachers could not help them to connect what they had learned in the class and with their daily lives. This indicates that in biology lessons, teachers just talk and transfer theoreticalor abstract knowledge and do not provide examples from daily life. In other words, the students could not understand why they were learning those topics or concepts in biology, as they could not relate them with their real lives. A lack of understanding the relationship between what was taught in the class and students' daily lives makes learning biology hard for students. This results in students' losing their motivation to learn biology and developing negative attitudes towards it. Kaya and Gürbüz (2002) and Çimer (2004) reported similar findingsin their studies of secondary students.

The final reason students have difficulties in learning biology, according to many participants, was the paucityof facilities, materials and lesson time. Some of them reported that as their schools did not have proper biology laboratories or enough teaching and learning materials, they did not carry out biology lessons as they expected. They stated that they could not conduct biologicalexperiments or observations in the laboratories or student-centered learning activities. All of these factors result in biology lessons being taught via a teacher- centered style or lectures (Çimer, 2004). As a result, biology lessons become boring and uninteresting for students. In the end, this negatively affects students' learning in biology. In addition, a few students indicated that lesson time for biology was insufficient. Although there were many topics, concepts or issues in the textbook and curriculum, the time allotted to teach them was not enough compared to the other science disciplines, such as physics or chemistry. To cover the whole textbook and curriculum in the term, teachers sometime had to teach biology in a quick way and to try to cover many concepts or issues in a one-hour lesson. Teaching so quickly may, of course, negatively affect students' learning biology, as they could not go into detail, ask many questions or conduct practical experiments. In summary, the participants of this study listed many important reasons for why they had difficulties in learning biology.

The students' views on what makes biology learning effective: Of 207 students, 163 responded to the question, "What do you think makes your biology learning effective?" Their responses

are summarized in Table 5. The students suggested various strategies or techniques for making their learning in biology effective: teaching biology through the use of visual materials, teaching through practical work, reducing the content of the biology curriculum, using various study techniques, teaching biology through connecting the topics with daily life, making biology teaching interesting, and increasing the number of biology questions in the Secondary Board Examination. While some of these suggestions are related to teachers, some are related to students themselves, and some relate to the biology curriculum.

A great majority of the students suggested that in biology teaching, teachers should use visual materials. As biology includes many abstract concepts and phenomenathat require observation, the participants indicated that they should see what they are learning. Therefore, they stated that in biology, if the teachers use various visual teaching and learning materials and tools, such as figures, models, computer simulations, videos, 3-D materials, and real-life objects, both the teaching and learning of biology may become more effective (Çimer, 2004, 2007). Because they defined effectiveness in learning as "retention of knowledge for a long time", they expressed that teaching biology through visual materials and tools helps them retain biological knowledge for a long time and thus remember or recall the information much more easily. Previous researches also promote teachers' using visual materials like pictures, posters, models, and computers in the lessons, which were found to be effective for making the lessons attractive and interesting for students (Mistler-Jackson and Songer, 2000; Peat and Fernandez, 2000). Recent studies have indicated that students remember best those ideas or concepts that are presented in a way to relate their sensory channels, for example, audio and visual representations, pictures, charts, models and multimedia (Reid, 1990; Joyce et al., 2000; Nayar and Pushpam,2000; Çimer, 2004). Teaching with visual materials can provide more concrete meaning to words, show connections and relationships among ideas explicitly, provide a useful channel of communication and strong verbal messages and memorable images in students' minds, and make lessons more interesting to students. (Cyrs, 1997; Harlen, 1999; Newton, 2002; Çimer, 2004, 2007). In the end, this makes their biology learning more effective.

More than half of the students indicated that in biology lessons, practical work should be done regularly. This indicates that current biology lessons include too few practical work sessions. These might be in the form of experiments, observations, field studies or projects.Rosenshine (1997) and Trowbridge et al. (2000) emphasize that for students to comprehend new ideas or concepts and construct their own knowledge, they needto see clear examples of what the new

ideas or skills represent. As stated above, because biology includes many abstract concepts and phenomena that require observation, students need to see what they are learning or to experiment with what is being taught. Practical work may help their learning through convincing them whatthey are being taught really exists or happens in the real world (Dillon, 2008). When students engage in practical work, they can test, rethink and reconstruct their ideas and thoughts (Çimer, 2007). Also, as students engage in learning while conducting experiments or observations, they can understand the topics and recall them easily because practical work allows students to learn the topics through various cognitive activities, for example, doing, watching, touching, talking, thinking, and discussing. Furthermore, Joyce et al. (2000) strongly emphasize that in learning new materials or skills, students should be given extensive opportunities to manipulate the environment because, according to Piaget (1978), students' cognitive structures will grow only when they initiate their own learning experiences. Therefore, the participants suggested that teaching through practical work in biology lessons might make biology teaching and their learning more effective.

About one-third of the students stated that making their learning effective in biology is related to their study skills or behaviors. They suggested various study strategies or tactics to make biology learning effective, such as solving questions, and regular reviews and taking notes. The students believe that if they solve various biology questions related to the biology topics being taught, they can learn biology more effectively because while solving questions, they can review the topics again and learn new ones as well. Additionally, sometimes solving questions require students to make connections between topics or with other disciplines as well. This facilitates their learning. As stated earlier, because the studentsconsider biology a verbal science and indicate that biology contains many verbal and abstract concepts, in order for the students to retain the information, repeating and reviewing the knowledge regularly helps the students recall biological knowledge much more easily. In addition, the students suggested that taking notes or the teacher's dictating the key concepts or issues in the lessons helps them learn biology effectively. The teacher's dictating notes about the key issues helps them focus on what needs to be learned instead of trying to learn everythingin the textbook or the teacher's lesson. Studying the notes being dictated by the teacher may save time for students, leaving extra time for repeating and reviewing and for studying for the exams. Similar findings are also reported by Çimer (2004).

Another suggestion made by the students for making biology learning effective is that it should be taught by connecting the topics with daily life. Regarding making

connections between the topic and students' daily lives, Trumper (2006) stated that a better fit between the curriculum and students' interests could lead to better cognitive and affective outcomes as well as increased enrollment in the sciences. Schaefer (1979) indicates thatif the concepts taught at school are not related to students' everyday lives, they may fail to use them adequately outside the school. Therefore, their knowledge may remain in the form of acquired isolated knowledge "packages". Effective learning requires students to apply newly acquired concepts or skills to different contexts (Gallagher, 2000; Yip, 2001; Çimer, 2007). As a result, they can achieve higher learning outcomes and use their knowledge or skills to solve the problems in their everyday lives. Therefore, as the students expressed, teachers should provide examples from the real world or students' daily lives so students can recognize easily what is being taught. Because they are familiar with them or can see them around them in their daily lives, they can understand and learn thosetopics easily. Also, the students suggested that while teaching biology, teachers should establish links betweenthe topics. This can help them see the big picture and learn in a more meaningful way.

Several students also indicated that teachers should make biology lessons interesting and attractive for students to learn more effectively. As stated earlier, biology includes much abstract and verbal knowledge and insufficient weekly lesson times, so biology lessons are run in a quick way and are mostly teacher centered (Çimer, 2004). In addition, using so many foreign words with less or limited explanation or definition also decreases students' attention to and interest in biology lessons. This makes biology lessons for students unattractive, irrelevant, meaningless and boring. They develop negative attitudes towards biology and its learning. As a result, they may fail to achieve highly in biology classes or exams. Many researchers indicate that there is link between students' attitudes towards biology and their learning environment (Adolphe et al., 2003; Chuang and Cheng, 2003; Çakıroğlu et al., 2003; Roth et al., 2006; Prokop et al., 2007; Zeidan, 2010). Therefore, as the participants suggested, teachers should try to make biology lessons interesting, fun and attractive. When teachers make the instruction personally more meaningful and relevant to students' lives and more enjoyable, interesting, and challenging, students have a higher intrinsic motivation to learn (Brophy, 1987; Çimer, 2007; McCombs, 2011). Forsyth and McMillan (1991) emphasize that variety in teaching activities revitalizes students' involvement in the course and their motivation. Teachers might accomplish this by using visual materials, teaching through practical work, giving examples fromstudents' daily lives, linking the topics to each other and explaining foreign terms or vocabulary more.

Conclusion

Finally, the students suggested that there should be more biology questions on the Secondary Board Examination, as having a small number of biology questions on the examination decreases students' motivation to study biology. This negative side effect of the Secondary Board Examination on students' attitudesand motivation to learn biology has previously been reported in Andhra Pradesh (Çimer, 2004; Yüzbaşılıoğlu and Atav, 2004; Telli et al., 2009; Pehlivan and Köseoğlu, 2010). The Secondary Board Examination covers the schools' subjects, but the number of questions from each school subject differs. The categories Turkish Literature and Grammar and Mathematics have the highest number of questions. Students usually allot their preparation time forthe exam according the number for questions of each subject. In this context, as biology is one of the school subjects with the lowest number of questions on the Secondary Board Examination, even though it has one of the most detailed curricula, many students put less emphasis on it. Instead, they prefer to study the other subjects, such as Mathematics, Physics or Turkish Literature and Grammar. This, in turn, negatively affects their learning and achievement in biology in school (Çimer, 2004). Thus, Sencar and Eryılmaz (2004) reported that few Turkish high school students preferred biology as their favorite subject. For these reasons, as suggested by the students, if there were more biology questions on the Secondary Board Examination, they might become more interested in learning biology and then put more focus and energy toward it.

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