Engaging Students in the Development of an Atmospheric Science Course: A Discourse Analysis

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Original Research Article

ABSTRACT

Aims: With increasing emphasis on learners-centered approach in teaching and learning, engaging students in course development and refinement is crucial. This study aims to foster a participatory approach in course development by engaging students in meaningful discourse at the early stage of an atmospheric science course.
Study design: This is a qualitative study which employed the grounded theory for data analysis.
Place and Duration of Study: The study was conducted in March 2021 in an international higher learning institution located in the Guangdong Province of China.
Methodology: This qualitative study invited a year 3 cohort of environmental science students taking an atmospheric science and pollution course in an international higher learning institution in China to participate in a meaningful discourse about the course in week 2 of the semester. Their responses were transcribed and the transcripts analyzed with NVIVO based on the grounded theory. The transcripts were coded, the themes were drawn and the relationship was probed.
Results: This study identified three overarching themes from the codes, namely assessment, course contents and learning activities, whose codes covered 4.5%, 17.8% and 23.1% of the text respectively. Codes for assessment comprise practical assignment and multiple-choice question, while those for course contents include black carbon, modelling, greenhouse gases, zero-carbon, and removal of Freon. Codes for learning activities include case studies, debate, field trips and

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quizzes. The words most frequently appeared in the transcripts are learning and field. The findings reflect expectations for interactive learning, simulation-based learning, authentic assignments and activities, experiential learning via field trips and problem-based learning. These are in line with the established pedagogies for environmental science.

Conclusion: This study shifts the paradigm of students' engagement in the increasingly learner-centered educational setting where students are proactively involved in course development in the early stage of teaching and learning instead of reactively involved through feedback collection at advanced stages.

1. INTRODUCTION

Environmental science has emerged as an integrative discipline spanning over multiple areas including natural sciences and social sciences [1]. Environmental science emphasizes the environmental aspects of natural sciences which are reflected in subjects such as environmental chemistry, environmental biotechnology, atmospheric science, water science and land remediation [2,3]. Besides, it covers certain aspects of social sciences, particularly in sustainable development, environmental management and environmental economics [1,4]. Due to its interdisciplinary nature, teaching and learning of environmental science has involved the adoption of diverse approaches to enhance the environmental knowledge and practical skills of students [5].

While there is a shift in the delivery of environmental science courses towards a learner-centered approach, educators are still playing a leading role in determining the pedagogical approaches, the contents of the courses as well as the types of assessment and learning activities [5]. The increasingly popular outcome-based education in many countries have propelled teaching and learning towards what learners are expected to achieve at the end of the course [6]. These course learning outcomes become the basis around which course contents, assessments and learning activities are designed, and educators are invariably the main, if not the sole players of the design and administration of these materials [6]. In increasingly learner-centered educational approaches, learners' participation in course design is often still rather limited. Learners frequently have little say on the course learning outcomes as these outcomes would need to be set before the delivery of a course starts. The involvement of learners in many instances, in a so-called learner-centered setting, is confined to providing feedback to various teaching and learning activities which are then used for continuous improvement of the course [7,8]. This format of learners' involvement could be perceived as reactive where problems are only captured after the teaching and learning process has started and advanced to a later stage. Conventionally, feedback has been gathered, but mostly after some forms of teaching and learning have taken place and it is used for the improvement of subsequent process [7].

Having gone through education processes, learners are likely to have developed ideas of how they expect teaching and learning should be, and these expectations could be course-specific. When learners are briefed about a particular course and provided with the course synopsis, they would have formed in their mind certain anticipations for the course [9]. These anticipations could be diverse as they differ among learners. Therefore, it is possible to incorporate these anticipations into the course through learners' participation at early stage of teaching and learning. Such participation also aligns with active and inquiry-based learning where learners are engaged in the teaching and learning process, and they dictate what they want to know [10]. The role of educators in this instance is to filter diverse expectations of learners to ensure their relevance to the course and realign them to the pre-set course learning outcomes which learners may not have much say about. In this manner, educators resemble facilitators as promulgated by the outcome-based education, in which they help learners to learn rather than feed learners with information [9].

In the teaching and learning of interdisciplinary environmental science, education for sustainable development has frequently received much attention in teaching research [11]. Sustainable development has gradually evolved to be a program on its own in many instances, though many of its courses still overlap with the more conventional environmental science [12,13]. The

lopsided attention to education for sustainable development is probably the result of the deliberate act of differentiating it from environmental education through the Thessaloniki Declaration to accentuate the concept of sustainability [14]. The differentiation was further reinforced through the Lüneburg Declaration made in 2001 urging universities to convert their commitment to sustainability into actions [14]. With education for sustainability in the global agenda and the United Nation's sustainability goals, many studies are dedicated to it, particularly those on the integration of education for sustainability into various levels of education, its pedagogical approaches, framework and its effectiveness [15,16,17]. In comparison to education for sustainable development, other common yet essential courses under environmental science such as atmospheric science and contaminated land are not as intensively studied [18].

Atmospheric and pollution science is an important course of environmental science dealing with chemistry and dynamics of the atmosphere as well as air pollutants [19]. The course could come under the specialized programs of atmospheric science and meteorology [20]. When placed under environmental science, the course is often adjusted to cover a wide range of atmospheric and pollutants' chemistry and dynamics without going into great depth. Studies related to the course are comparatively limited. Dimitriou and Christidou studied the conception and knowledge of students aged 7-13 years about air pollution but did not extend this to college-level students [21]. Sinclair and Marshall designed a participatory approach in the teaching and learning of atmospheric science involving collaboration with high schools in the collection of atmospheric data including precipitation, temperature and relative humidity [19]. This implies the possibility of incorporating university-level research into secondary schools' learning. Harrison et al. designed a learning resource which could engage primary school students in gathering and analyzing air quality data from official air quality website [22]. Schultz et al. developed a similar learning resource earlier called ManUniCast which is essentially a real-time weather and air-quality forecasting portal [23]. Gumala et al. conducted a study among pre-service elementary school teachers to examine their conception of air pollution [24]. Mandrikas et al. reflected upon the effectiveness in the design of an air pollution course which

embedded experimental study and educational software in teaching and learning [25]. They found the design beneficial to the use of correct terms in scientific discourses while garnering deeper insight into air pollution events.

A literature search on the teaching of atmospheric science and pollution reveals that the latter received more interest in educational research compared to the former and most of the research involved development and testing of new resources, as well as gauging the conceptions of the subjects about the related courses and interventions to enhance understanding. Studies dedicated to the teaching of atmospheric science are far and few. Through an open-ended survey among students and faculty members on atmospheric sciences, Roebber pointed out that curricular design was often aligned to the styles of faculty members rather than students, and that faculty members were also aware of the need for change. The study called for a case-study-driven approach in the reorganization of the curriculum [26]. Coleman and Mitchell introduced high-altitude balloon research into atmospheric science classes to encourage active learning and solving of real-world problems [27]. Similarly, Yang et al. (2010) advocated an experiment-teaching system for atmospheric science [28]. These studies recommend the adoption of new active approaches in delivering atmospheric sciences from the viewpoints of educators, and students have not been involved in the process of curricular or course reform. With learner-centered approach to teaching and learning increasingly emphasized, particularly in outcome-based education, learners' participation in the teaching and learning process is crucial and this participation can be extended to the design of a course and even the establishment of course learning outcomes [29]. This study advocates a proactive stance in learners' participation in the teaching and learning process by exploring their expectations of an atmospheric science course. It aims to understand and integrate learners' expectation into teaching and learning of the course at an early stage, and reflect on the feasibility of doing so.

2. METHODOLOGY

2.1 Course Background

Atmospheric science and pollution has been offered to year 3 environmental science students of a college in China as a compulsory core. The

course covers an array of themes ranging from earth's atmosphere, weather and climate, atmospheric heat transfer and radiative forcing, climate change, air pollution phenomenon, as well as atmospheric stability. The focus of the course is to provide an overview of atmospheric science without delving into the physics. It contains more chemistry particularly of air pollution than physics. This course has adopted outcome-based approach with the course learning outcomes and the teaching and assessment methods clearly made known to the students. It encourages learners' participation through group discussions and activities. Being learner-centered, it has aimed to provide feedback to learners' work in a timely manner and invited feedback from learners in teaching evaluation.

2.2 Data Collection and Analysis

The learners, consisted of year 3 students, have experienced various learning processes in the environmental science program and are familiar with how feedback is commonly gathered. They are deemed sufficiently mature to provide useful inputs. In this study, all 40 students taking the course were involved in the meaningful discourse centering around the development and their anticipations of the course [30]. The discourse was conducted in the second week of the course after the learners had been briefed about the course outline and provided an introduction of the course. The course outline was designed to flexibly incorporate the inputs of the learners gathered from the discourse. They were asked to provide their inputs in helping to refine the course in all aspects and this includes their anticipations

of the course. During the discourse, depending on levels of detail of the responses, more specific questions were posted to encourage responses. Examples of these questions are 1) What contents do you wish to be in the course? 2) What kind of activities would you like the course to have? 3) How do you think the course can be made meaningful to you? 4) Would you provide more details of the activities suggested?

The audio responses were recorded and analyzed using grounded theory. They were then transcribed to text using NVIVO [31]. Coding was conducted with NVIVO on the text for concepts related to the learners' inputs and anticipations, and these concepts were grouped into higher categories. Coding of the transcribed responses proceeded until theoretical saturation was reached and additional data did not contribute to the expansion of categories or relationships [32]. NVIVO permits graphical representation of the percent coverage of each category and its underpinning codes, as well as the generation of a word cloud on words or phrases most commonly repeated in the transcripts [31].

3. RESULTS AND DISCUSSION

3.1 Results

The discourse analysis yielded three themes or categories, namely assessment, course contents and learning activities. The coverage of each theme in the transcripts is shown in Fig. 1. Codes on learning activities covered 23.1% of the text, those on course contents covered 17.8% and those on assessment only 4.5%.
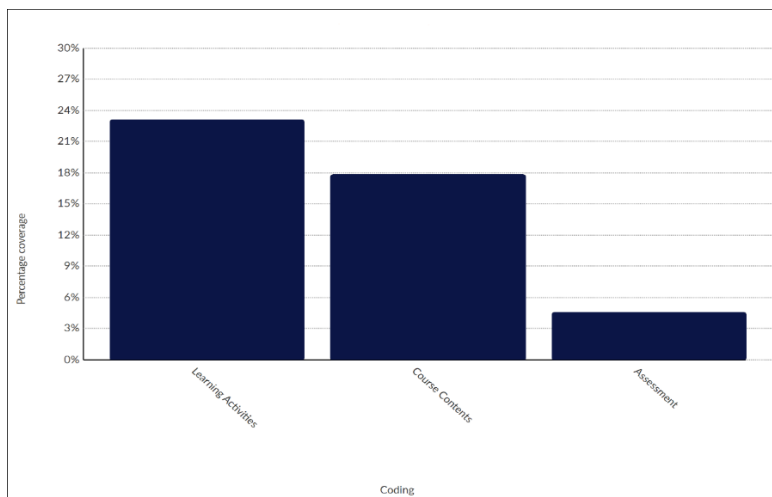

Fig. 1. Percent of thematic coverage based on coding

Under learning activities, the codes comprise case studies on popular topics, debate, field trips, quizzes based on multiple choice questions, working on practical environmental cases which permit application of knowledge and discussion on environmental news particularly those related to atmosphere and pollution. The students also suggested places for field trip namely the weather bureau and the Qi'ao Island in the Guangdong Province. Case studies were invariably associated with the application of knowledge which implies the desire of the students to apply what they learn in problem-solving. Quizzes were related to the concepts of competitiveness and participation, indicating that the students were keen on quizzes conducted in a competitive environment which would enable high-scorers to be identified. They also associated quizzes to participation and deemed that quizzes were a good way to engage learners. Multiple choice questions seemed to be their preferred format of quizzes. Besides, they defined the criteria of case studies which consisted of practical cases and popular topics.

Under the theme of course contents, the codes range from black carbon, modelling software such as Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS), dealing with the effects of greenhouse gases, live a zero-carbon life, to cleaning the atmosphere from Freon, properties and reactions of different air pollutants and weather forecast. The students seemed to propose more contents on the pollution aspect especially on pollution caused by black carbon and Freon. They were also interested in climate issues as reflected from their desire to know about greenhouse gases and zero-carbon life. These two concepts are apparently linked to global warming or climate change [33,34]. In terms of the atmospheric science domain, only weather forecast was mentioned. The codes indicate an inclination towards pollution chemistry, for instance the properties and reactions of air pollutants. The students were eager to perform simulation through learning modelling software, and solve problems particularly those related to removal of Freon and stopping carbon emission.

The assessment codes are practical assignment and multiple-choice questions. Multiple-choice questions were perceived as both a learning activity and assessment. As a learning activity, quizzes in the form of multiple-choice questions are conducted to promote positive com-petition and engagement in class, and scores of the quizzes do not contribute to the final grades. As an assessment, the scores students obtained from attempting the quizzes would add to final grades. Again, practicality appears as an assessment code which reiterates students' anticipation of course contents that they could apply to solve real problems.

The words most frequently appeared in the transcripts are learning and field, followed by trip and atmosphere. Words such as practical, debate, interesting and carbon appeared relatively less frequently. This indicates that the students were really keen on having field trip as a learning activity. The students portrayed positive sentiment while providing their inputs to assist the dynamic development of the course. They were particularly excited when talking about field trip despite potential restriction on field trip caused by COVID-19 during the undertaking of this study. Generally, the college students had resumed face-to-face learning when this study was conducted and vaccines for COVID-19 were rolled out. However, it remained uncertain on whether visiting government meteorological facilities was already allowed [35,36].
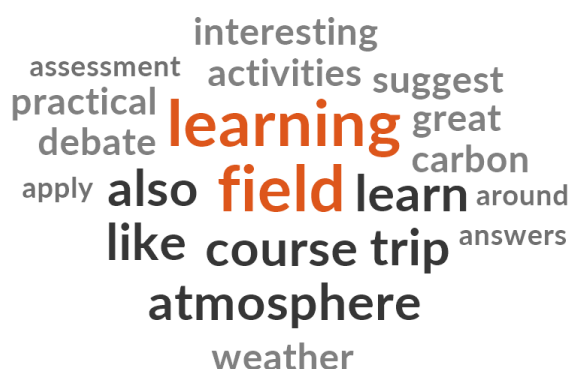

Fig. 2. Words most frequently appeared in the transcripts of the discourse

3.2 Discussion

The qualitative discourse analysis yields insight into a participatory approach in engaging students in the development of the course which aligns with the pedagogical approaches advocated by other authors. Having field trip, debates and practical case studies as learning activities agrees with the pedagogical reform of environmental science courses promulgated by Dresner et al. consisting of field trips, data analysis and synthesis which resulted in better ability of learners to answer cognitively challenging questions [1]. Fieldwork particularly was regarded as the main contributor to the improved understanding [1]. Dimitriou and Christidou tested students' preconception of atmospheric pollution to better formulate in-class discussion on air pollution. In this study, the college-level students also anticipated discussions particularly those on environmental news [21]. This would permit them to relate their knowledge to environmental incidents in the real life.

According to Knox and Ackerman, weather forecasting was the main reason students enrolled in atmospheric science courses [20]. In this study, atmospheric science and pollution is a core subject that the environmental science students need to take. Probing their anticipations revealed the eagerness of some students to learn about weather forecast. However, it was uncertain if learning about weather forecast was the main interest of the students and weather forecast has not been included in the course syllabus. It was only in this study that certain students expressed their interest to learn about weather forecast and to visit the weather bureau. Other scholars have attempted to create online weather and air-quality forecasting resources [22,23]. These resources, if made available to the public, could be employed for this course to facilitate the learning of weather forecasting.

Mandrikas et al. revealed that learning activities incorporating authentic context to estimate air pollution resulted in better understanding of temperature inversion, as well as the relation between topography and level of air pollutants [37]. This supports the preferences of the students for practical environmental cases and practical assignment. It demonstrates that authentic learning could facilitate the learning of the course contents by allowing students to know their practical implications. Besides, students are better able to apply the knowledge in problem-

solving [37]. With limited pedagogical knowledge, the students' responses seem to reflect established and sound pedagogies in the teaching and learning of atmospheric science and pollution.

Furthermore, the students have developed some idea about the use of modelling or simulating tools such as LAMMPS. It implies that the students recognize simulation-based learning as a channel in deepening and consolidating their knowledge of atmospheric and pollution science. Nonetheless, this presents a situation where educators need to actively evaluate the appropriateness of the information provided by students. LAMMPS is program which simulates physical movements of atoms and molecules. It is not usually used to simulate atmospheric dynamics or pollutants' dispersion [38]. While recognizing the desire of students to engage in simulation-based learning, educators, in certain instances, have to exercise discernment in selecting the right program. In this case, air pollution dispersion software would be more relevant [39].

In this study, the responses of the students were inclined towards air pollution science and this might indicate their familiarity to air pollution science rather than atmospheric science. Literature related to the teaching and learning of atmospheric science and pollution also leans towards air pollution. The students also linked this course to the concepts of global warming such as greenhouse gases and carbon which form a topic of the course. The teaching of climate change and global warming receives significantly higher interest in educational research compared to atmospheric science and pollution. Their anticipations of the course show agreement with the common pedagogies adopted for teaching climate change and global warming for instance debate [40], modelling [41] and interactive learning including the use of interactive technologies and inquiry-based learning [42]. As the students also related the course to removal of Freon which causes ozone depletion, there seems to be a need to address misconceptions that equate ozone depletion to climate change or global warming. These misconceptions have been reported among pre-service and in-service teachers of environmental education [27].

The study faces certain limitations. Coding to draw ideas and themes from the transcripts can be subjective. Organizing the codes into

categories often relies on the judgment of the researchers though supported to certain extent by the appropriate theoretical frameworks [32]. Theoretical frameworks are not always available for all the codes. However, the absence of theoretical frameworks may work to support the novelty of certain codes and the adoption of grounded theory in qualitative research to exegete new insights. It may not be possible to capture all the ideas and themes from the extensive responses during the coding processes, leaving a potentially non-exhaustive list of codes which may constrain the new theories formed. Besides, this study was conducted on a particularly cohort of students of a higher learning institution. It could be extended to students taking similar courses in other institutions to confer a comparative perspective. A progressive involvement of students in the design, development and continuous improvement of a course could be implemented to confer students a more important role in course development.

4. CONCLUSION

Echoing the learner-centered approach in teaching and learning, this study attempted to collect the inputs of students concerning a course in its early stage in contrast to the common practice which gathers students' feedback at more advanced stages of teaching and learning. In this manner, the inputs could directly influence the design and administration of the course. This study shows that the students, having experienced tertiary education, have developed ideas of the teaching and learning process they desire. These ideas are characterized by interactive learning, simulation-based learning, authentic assignments and activities, experiential learning via field trips and problem-based learning. These approaches are in agreement with the established pedagogies in teaching environmental science. This study contributes to the participatory development and refinement of a course to enhance students' learning experience, address their needs and improve their achievement of learning outcomes. It promulgates a strategy that engages students in course design and development process. Future studies can comparatively examine the inputs of students in other universities or colleges offering similar courses. Future studies can also aim to propose and test a more structured participatory approach and framework in course development.

CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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