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Abstract

A major objective of statistics education is to develop students' statistical literacy that enables them to be educated users of data in context. Teaching statistics in today's educational settings is not an easy feat because teachers have a huge task in keeping up with the demands of the new generation of learners. The present day students have higher expectations in terms of classroom pedagogy particularly in the use of creative and engaging methods to create a significant learning experience for them. This paper discusses how students' statistical literacy can be fostered by creating a more integrated statistics course using the Fink's Taxonomy of Significant Learning.

Keywords: Taxonomy, integrated statistics course, significant learning

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Potenciando la Alfabetización Estadística de los Estudiantes a Través de Experiencias de Aprendizaje Significativas

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Abstract

Un objetivo principal de la educación estadística es desarrollar la alfabetización estadística de los estudiantes para que les capacite como usuarios con cierto nivel de competencia en el manejo de datos en contexto. Enseñar estadística en los contextos actuales de educación no es fácil porque los/as maestros/as tienen una gran tarea para responder a las demandas de la nueva generación de estudiantes. Actualmente los/as estudiantes tienen altas expectativas en términos de pedagogía de aula y particularmente en el uso de métodos creativos y participativos, para crear experiencias de aprendizaje significativas para ellos/as. Este artículo discute cómo la alfabetización estadística de los/as estudiantes se puede potenciar a través de la creación de un curso de estadística más integrado, usando la taxonomía de Fink sobre el aprendizaje significativo.

Keywords: Taxonomía, curso de estadística integrado, aprendizaje significativo, alfabetización estadística

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GAISE College Report states that the ultimate goal of statistics teaching and learning is statistical literacy (Franklin et al., 2005). Statistical literacy is required by consumers, citizens and professionals for daily personal choices and the nation's economic future. In the literature, statistical literacy is often used interchangeably with statistical thinking and statistical reasoning (Chance, 2002). This is because considerable amount of overlap among the three learning domains is observed when they are treated as theoretical constructs although they were originally created to formulate more meaningful goals for statistics education (Broers, 2006; Bude, 2006).

In his paper, that essentially discussed teaching statistics with real data, Gould (2010) pointed out that statistics teaching has always been difficult and the number of statistics educators who failed was increasing by the 1980's. In fact, according to Carnell (2008) students in general perceive statistics to be a difficult and unpleasant subject. Producing students who are statistically literate that is students who are informed consumers of statistical information is one of the challenges of the present day statistics education (Chance, 2002). Among others, this requires students to be able to retain the knowledge acquired in statistics classrooms and to apply them in different, out of classrooms real-life settings.

A probable hindrance to successful statistical learning is that teachers do not make the learning meaningful to their students. As such, students are not able to comprehend and appreciate the importance of statistics in their life and eventually lose interest in this subject. In this paper, the idea of an integrated statistics course to promote significant learning experience for the students is presented. The characteristics of this integrated statistics course are outlined based on the Taxonomy of Significant Learning introduced by Dr. L. Dee Fink in the 21st century.

Fink's Taxonomy of Significant Learning

The Taxonomy of Significant Learning otherwise known as Fink's Taxonomy was introduced by Dr. Fink as an extension to the infamous Bloom's Taxonomy of Educational Objectives. As we know, Bloom's Taxonomy discusses students' learning from the cognitive, affective and psychomotor domains with the cognitive domain being the more frequently discussed one. Bloom's Taxonomy has been extensively applied in many

fields of education and still serves as a valuable tool in assessing students' learning of various subjects (e.g., Crowe, Dirks & Wenderoth, 2008; Thompson, Luxton-Reilly, Whalley, Hu & Robbins, 2008). However, Fink felt that Bloom's Taxonomy does not include "*important kinds of learning*" (Fink, 2003c, p.2). Hence, Fink's primary motivation in developing the Taxonomy of Significant Learning is to support and promote students' chosen significant learning experiences which includes but not limited to learning how to learn, leadership and interpersonal skills, ethics, and communication skills (Fink, 2003c).

Table 1
The categories of the Taxonomy of Significant Learning

Categories	Description	Special value
Foundational Knowledge	Able to understand and remember information and ideas	Basic understanding
Application	Involve engagement in different actions and kinds of thinking, and developing skills	Useful
Integration	Connecting ideas	Intellectual power
Human Dimension	Better understanding of self and others for more effective interaction	Human significance
Caring	New feelings, interests and/or values	Energy
Learning How To Learn	Learn about the process of learning	Greater effectiveness

Fink defines significant learning as learning that brings about a lasting change in the learner's life (Fink, 2003c). The six categories of learning described by the Taxonomy of Significant Learning are: (i) foundational knowledge, (ii) application, (iii) integration, (iv) human dimension, (v) caring, and (vi) learning how to learn. Table 1 presents a summary of the description and the special value attached to the six categories of learning

extracted from Fink (2003c). Unlike the Bloom's Taxonomy where elements in the domains are hierarchical, the categories of Fink's Taxonomy are interactive with significant learning being at the centre of the intersections of the different kinds of learning (see Fink, 2003a).

Two important features of the interactive nature of the categories of Fink's Taxonomy are: (i) each category of learning is related to the other categories of learning, and (ii) achieving one category of learning enhances the possibility of achieving the other categories of learning. In a nutshell, students would have had significant learning experience in a course that is able to support and promote the six categories of learning. The next section discusses the components of an integrated statistics course.

Components of an Integrated Statistics Course

The aim of an integrated course is for students to be more engaged in their learning in order to achieve more important kinds of learning. Thus, an integrated course should be learning-centered, systematic and of course integrated (Fink, 2007). The model of an integrated course contains three major components which are: (i) learning goals, (ii) teaching and learning activities, and (iii) feedback and assessment. These components are inter-related to one another and are influenced by situational factors (see Fink, 2003a, p.2). Information about the important situational factors is used to make decisions with regards to the three major components. This includes information about specific and general contexts of the teaching and learning situation, nature of the subject, and characteristics of the teacher and the learners (Fink, 2003b).

Learning Goals

Fink's model of an integrated course design (Fink, 2003a, 2007) proposes more exciting and challenging learning goals. Pertaining to the six categories of learning in the Taxonomy of Significant Learning, the learning goals for an integrated statistics course should require students to:

a) understand and remember key statistical concepts and terminologies.
b) know how to use the learned statistical contents.
c) be able to relate the statistics course to other subjects.

d) identify the personal and social implications of knowing statistics.
e) value the statistics course.
f) value learning further about statistics.
g) know how to continuously learn about statistics after the course is completed.

By asking two important questions: 'What would the impact of the integrated statistics course be on students after the completion of the course?' and 'What distinguishes students who have taken the course from those who have not?', emphasis of the learning goals should be on students' critical thinking, creative use of statistical knowledge, learning to solve real-world problems, changing the ways students view themselves and others, and commitment to life-long learning (Fink, 2003b).

Teaching and Learning Activities

Fink (2003a) stressed that new kinds of teaching and learning activities are needed to be able to create significant learning experiences for students in an integrated statistics course. This can be achieved by incorporating more active learning activities into the course. The working theory for active learning is that students learn better when they are actively engaged in the learning process. The types of activities in active learning include simulations, guided design, problem solving and case studies. More importantly, the teaching and learning activities in an integrated statistics course must support the learning goals of the course.

Active learning is not a new concept in the teaching and learning of statistics. Pfaff and Weinberg (2009) used hands-on data generating activities to enhance students' understanding of statistical concepts. Meanwhile, Weltman and Whiteside (2010) found that active learning was more beneficial for the lower ability than the higher ability students for a group of introductory business statistics students specifically.

Fink (2003a, 2007) provided a holistic view of active learning consisting of three modes or three kinds of learning. They are: (i) information and ideas, (ii) experience, and (iii) reflective dialogue. The learning activities in acquiring information and ideas usually are out-of class readings or in-class lectures while the learning activities in acquiring experience consists of problem solving and decision making exercises for instance (Fink, 2007).

On the other hand, the reflective dialogue can be carried out through

journal writing or portfolios for self-reflection, or dialogues with other students and the teacher (Fink, 2003a).

Feedback and Assessment

The purpose of feedback and assessment is to know if the learning goals of the integrated statistics course have been achieved and whether the teaching and learning activities used had been successful in achieving those learning goals. Following Fink's (2003a, 2003b) proposal, the feedback and assessment of an integrated course should contain the following key elements:

a) forward-looking assessment,
b) criteria and standards,
c) self-assessment,
d) FIDeLity feedback which is the acronym for *F*requent, *I*mmediate, *D*iscriminating and delivered *L*ovingly feedback.

Forward-looking assessment involves real-life contexts in which students will need to use their statistical knowledge. Criteria and standards serve as yardsticks to distinguish good work from poor work (Fink, 2003b) and are needed in assessing complex learning (Fink, 2007). Students must be given opportunities for self-assessment, individually and in groups, because in later life after the completion of the course they will need to do this (Fink, 2003a).

The FIDeLity characteristics include feedback, which is given immediately and frequently that is at least on weekly basis. Feedback must also show clear distinction between the good and poor work and teachers must be empathic in delivering the feedback (Fink, 2003b). More importantly, the feedback and assessment in a learner centered integrated statistics course should be "*educative*" instead of "*audit-ive*". This means the goal of feedback and assessment should be enhancement of the quality of learning (educative) instead of for grading purposes (audit-ive) (Fink, 2003b).

Fostering Statistical Literacy

Although different definitions of statistical literacy can be found in literature, they have similar and sometimes coinciding descriptions (e.g.,

Chance, 2002; Gal, 2000; Garfield, 2002; Rumsey, 2002; Watson, 1997). Watson's (1997) definition of statistical literacy and the definition in the GAISE College Report include understanding of basic statistical terminologies and symbols while definitions by Gal (2000), Garfield (2002) and Rumsey (2002) emphasize on interpretive and critical thinking skills. In addition, the definitions by Chance (2002), Gal (2000) and Rumsey (2002) involve making sense of and critically evaluating statistical information, and reasoning through a procedure for decision-making and problem solving.

Regardless of the definitions that we want to adopt in designing an integrated statistics course, the goal is for students to be able to understand and work with data and other statistical information in the process of making educated statistical analyses of the data and the information, and then to be able to effectively communicate the results and findings to other statisticians and non-statisticians verbally and in writing. The components of the learning goals in Fink's model of integrated course design as discussed in the previous section helps to achieve this particularly where students are required to understand the statistics and use the statistics in their present field and other fields. In addition, by being able to value the course and the learning of statistics, students' appreciation of data and the use of data in day-to-day problem solving and decision-making will be enhanced.

There are plenty of interactive tools and teaching methods resources available to foster students' learning of statistics using the active learning strategies. For instance, the International Statistical Literacy Project (ISLP) website provides an online repository of international resources and news in statistical literacy. Other examples are the online resources the Electronic Encyclopedia of Statistical Examples and Exercises, and the Data and Story Library developed by the National Science Foundation (NSF) (Hall & Rowell, 2008). As said by Garfield and Ben-Zvi (2007), technology helps students to learn the basic statistical concepts and to understand the abstract statistical ideas by creating an environment that is interesting, engaging and motivating for the students.

Conclusion

Students' statistical literacy can be fostered by creating a significant learning experience for the students through an integrated statistics course. The basic design of the course should include in-depth analysis of situational factors, significant learning goals, educative feedback and assessment, active teaching and learning activities, and the integration or alignment of these major components (Fink, 2003a). The next step then is to create a course structure and to select an instructional strategy, and then integrating both into an overall scheme and learning activities. In order to achieve significant learning experience, the three key components in a model of integrated statistics course must be integrated which means they support and reinforce each other (Fink, 2003c).

The two primary steps for proper integration of the major components in the design of an integrated statistics course is to review decisions made regarding the three major components of the integrated statistics course and to create a dynamic combination and a sequence of learning activities (Fink, 2003b). Although is time and energy consuming, this is offset by the potential benefit to the students in terms of their significant learning in these courses. Moreover, because the focus of an integrated statistics course is not on standardized tests but on building students' conceptual understanding, it helps promote learning of the less performing students as well. Especially in a classroom with a range of high performing to low performing students, an integrated statistics course will be ideal in creating individualized significant learning experience for the students so that all students are included in the learning process towards fostering statistical literacy.

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