Mesure et évaluation en éducation

Developing the PAOCS Scale (Perceptions and Attitude toward Oral Communication in Science) for Postsecondary Science Students

Simon Langlois et Caroline Cormier

Volume 44, numéro spécial, 2021

URI : https://id.erudit.org/iderudit/1100056ar
DOI : https://doi.org/10.7202/1100056ar

Aller au sommaire du numéro

Éditeur(s)

ADMEE-Canada

ISSN

0823-3993 (imprimé)
2368-2000 (numérique)

Découvrir la revue

Citer cet article

Langlois, S. & Cormier, C. (2021). Developing the PAOCS Scale (Perceptions and Attitude toward Oral Communication in Science) for Postsecondary Science Students. *Mesure et évaluation en éducation*, *44*(spécial), 89–128. https://doi.org/10.7202/1100056ar

Résumé de l'article

L'habileté à communiquer oralement est importante en sciences, mais peu d'outils évaluent les perceptions et l'attitude d'étudiants de programmes scientifiques envers la communication orale en sciences. Cette recherche propose la création, d'une part, d'un modèle théorique de la communication orale en sciences et, d'autre part, d'un questionnaire conforme à ce modèle intitulé Perceptions et attitude envers la communication orale en sciences (PACOS) pour des étudiants du postsecondaire. Un échantillon total de 1295 étudiants collégiaux québécois en sciences de la nature a participé à cette recherche en répondant aux trois versions successives du questionnaire PACOS tout au long de son élaboration. Cinq facteurs ont été identifiés par des analyses en composantes principales (ACP) et par une analyse factorielle confirmatoire (AFC), soit le plaisir, l'anxiété, la perception de la pertinence ainsi que deux aspects du sentiment d'efficacité personnelle lors d'une communication orale en sciences (SEP_{COS}) qui ont émergé lors de l'élaboration du questionnaire : le SEP_{COS} « normes et contenu », qui porte sur l'efficacité à bien s'exprimer oralement, et le SEP_{COS} « sens du spectacle », qui décrit plutôt la façon d'être et de capter l'attention du public. L'évaluation globale du PACOS montre que ce questionnaire a de bonnes qualités psychométriques et que les facteurs obtenus lors du processus de validation soutiennent le modèle théorique.

Mesure et évaluation en éducation, 2021, vol. 44, translation issue, 89-128

Developing the PAOCS Scale (Perceptions and Attitude toward Oral Communication in Science) for Postsecondary Science Students

Simon Langlois
Cégep Marie-Victorin

Caroline Cormier
Cégep André-Laurendeau

Key words: perceptions, attitude, self-efficacy, scientific oral communication

The ability to communicate orally is important in science, but few tools assess students' perceptions and attitude toward scientific oral communication in scientific programs. This research developed the Perceptions and attitude towards oral communication in science *(PAOCS) questionnaire for postsecondary students with the theoretical model associated. A sample of 1,295 Quebec college students in a natural sciences program participated in this research, responding to the three versions of the questionnaire during the stages of its development. Principal component analyses (PCA) followed by a confirmatory factor analysis (CFA) made it possible to identify five factors for the PAOCS questionnaire: pleasure, anxiety, perceived relevance, and two aspects of self-efficacy (SE_{OCS}), namely the Norms & Content SE_{OCS}, which relates to the effectiveness in expressing oneself orally, and the Showmanship SE_{OCS}, which describes rather how to be dynamic and capture the attention of the audience. The overall evaluation of the PAOCS shows that this questionnaire has good psychometric qualities and that the components obtained during the validation process support the theoretical model.*

Mots clés : perceptions, attitude, sentiment d'efficacité personnelle, communication orale en sciences

L'habileté à communiquer oralement est importante en sciences, mais peu d'outils évaluent les perceptions et l'attitude d'étudiants de programmes scientifiques envers la communication orale en sciences. Cette recherche propose la création, d'une part, d'un modèle théorique de la communication orale en sciences et, d'autre part, d'un questionnaire conforme à ce modèle intitulé Perceptions et attitude envers la communication orale en sciences *(PACOS) pour des étudiants du postsecondaire. Un échantillon total de 1295 étudiants collégiaux québécois en sciences de la nature a participé à cette recherche en répondant aux trois versions successives du questionnaire PACOS tout au long de son élaboration. Cinq facteurs ont été identifiés par des analyses en composantes principales (ACP) et par une analyse factorielle confirmatoire (AFC), soit le plaisir, l'anxiété, la perception de la pertinence ainsi que deux aspects du sentiment d'efficacité personnelle lors d'une communication orale en sciences (SEP_{COS}) qui ont émergé lors de l'élaboration du questionnaire : le SEP_{COS} « normes et contenu », qui porte sur l'efficacité à bien s'exprimer oralement, et le SEP_{COS} « sens du spectacle », qui décrit plutôt la façon d'être et de capter l'attention du public. L'évaluation globale du PACOS montre que ce questionnaire a de bonnes qualités psychométriques et que les facteurs obtenus lors du processus de validation soutiennent le modèle théorique.*

Palavras-chave: percepções, atitude, senso de autoeficácia, comunicação oral em ciência

A capacidade de comunicar oralmente é importante em ciências, mas poucas ferramentas avaliam as perceções e atitudes dos alunos em programas científicos em relação à comunicação oral em ciências. Esta investigação propõe a criação, por um lado, de um modelo teórico de comunicação oral em ciências e, por outro, de um questionário de acordo com esse modelo intitulado Perceções e atitude em relação à comunicação oral em ciência (PACOS) para estudantes do pós-secundário. Uma amostra total de 1.295 estudantes universitários de ciências naturais do Quebeque participou nesta investigação, respondendo a três versões sucessivas do questionário PACOS ao longo da sua elaboração. Cinco fatores foram identificados através de análises de componentes principais (PCA) e por uma análise fatorial confirmatória (CFA), a saber, prazer, ansiedade, perceção de relevância, bem como dois aspetos do sentimento de autoeficácia durante a comunicação oral em ciências (SEP_{COS}) que surgiram durante a elaboração do questionário: o SEP_{COS} «normas e conteúdo», que diz respeito à eficácia de se expressar oralmente, e o SEP_{COS} «sentido do espetáculo», que descreve antes o modo de ser e de captar a atenção do público. A avaliação global do PACOS mostra que este questionário possui boas qualidades psicométricas e que os fatores obtidos durante o processo de validação corroboram o modelo teórico.

Authors' note: Correspondence relating to this article may be submitted to simon.langlois@collegemv.qc.ca and caroline.cormier@claurendeau.qc.ca. We would like to thank the *ministère de l'Enseignement supérieur* for the financial support provided through the *Programme d'aide à la recherche sur l'enseignement et l'apprentissage* (PAREA). We would also like to thank Claude-Émilie Marec for her valuable advice and extensive contributions to this article.

Introduction

Research in the area of oral communication skills is a fairly recent development and receives little attention from researchers, especially in the natural sciences (De Grez et al., 2009; Kulgemeyer and Schecker, 2013). However, in recent years there has been a global consensus that students need to develop these skills in order to better meet the qualifications sought by employers (Casner-Lotto and Barrington, 2006; Mercer-Mapstone and Matthews, 2017). From a societal perspective, a student who develops these skills may be in a better position to participate in public and scientific debate.

For these reasons, many postsecondary programs around the world now include acquisition of these skills as one of their overall goals (Australian Qualifications Framework, 2013; Brewer and Smith, 2009; MELS, 1998; Rajput, 2017). However, instruction in oral communication is frequently inadequate, and undervalued when compared to written communication (Chan, 2011; Dumais and Granger, 2017). As a result, students often fail to master this skill by the time they leave university (Mulder et al., 2008). Indeed, many students report that they do not see the relevance of good speaking skills to their future careers in science (Leggett et al., 2004).

The fact remains that it is possible to teach students to communicate effectively in their oral presentations (Chan, 2011). In one of the rare studies on the subject, McLaren (2019) demonstrated that a ten-week training program in oral communication in the sciences could significantly change a student's attitude toward this task. The setting for this demonstration was an analytical chemistry course, with evaluation conducted before and after the intervention. To reach this conclusion, the author developed an instrument that measures attitude using items that address students' motivation concerning oral presentation skill development, the importance they attribute to these skills, and the student's perception of his or her speaking ability. In another study, Dwyer and Fus (2002) employed several

scales that complement those of McLaren (2019) by measuring self-efficacy (SE) (Bandura, 1986; Pintrich & de Groot, 1990), public speaking anxiety (McCroskey, 2009) and self-perceived public speaking competency (Ellis,1995).

To our knowledge, apart from the work of McLaren (2019) and the scales used by Dwyer and Fus (2002), there are few tools available to document and assess the attitude of postsecondary students toward oral communication, particularly in the sciences. In addition, these scales have certain limitations. The self-report scales used by Dwyer and Fus (2002) focus on undergraduate students' self-efficacy (SE), their anxiety about making an oral presentation, and their oral proficiency, but do not incorporate the concepts of attitude, perceived relevance and enjoyment in oral communication (Boudreau et al., 2018). Moreover, their scales are not science-specific, whereas science has well-documented specificities for oral communication, such as the presenter's understanding of the scientific content or the ability to adapt one's presentation to the target audience through the use of examples and analogies specific to the scientific disciplines (Dunbar et al., 2006; Kerby & Romine, 2009; Kulgemeyer, 2018). McLaren (2019) proposes a more global scale of attitudes toward oral communication in the sciences (OCS). However, this scale does not take into account the student's self-efficacy toward oral communication in science (SE_{ocs}) and does not appear to have undergone a validation process (e.g., factor structure analysis), which would have differentiated its various constructs.

From a conceptual perspective, attitudes toward OCS have yet to be delineated. In general, attitudes are often measured in terms of their constituent elements, including cognitive beliefs (Jones and Leagon, 2014; Tsai, 2002), self-efficacy (Bursal, 2012; Riggs and Enochs, 1990) and enjoyment (Kazempour, 2014; Zembylas, 2002). However, measuring a single element does not take into account the multidimensional nature of attitude or the dynamic interaction that exists between these elements (Barmby et al., 2008; van Aalderen-Smeets et al., 2012).

In their reflection of teachers' attitudes toward science and science teaching, van Aalderen-Smeets et al. (2012) propose a new framework that is largely based on the theory of planned behaviour (Ajzen, 2001) and includes seven attitude elements. This framework appears to be promising,

as it not only places the emphasis on the interaction of attitude elements with each other, but also suggests that the end result of these interacting attitude elements is observed behaviour.

In light of the relative lack of tools and specific frameworks dealing with attitudes toward OCS, this article will first propose a theoretical model of perceptions and attitude toward oral communication in science, a model constructed from the main concepts with which they are associated: SE, anxiety, enjoyment and perceived relevance of OCS. These concepts correspond to four of the seven elements in the attitude model created by van Aalderen-Smeets et al. (2012) and are organized according to the same theoretical structure. The article then introduces a scale aligned with the proposed theoretical model, which is entitled Perceptions of and Attitude toward Oral Communication in Science (PAOCS) and is based on the methodological approach.

Conceptual framework

We start by introducing our theoretical model of perceptions and attitude toward oral communication in science, then provide a description of each of its constituent concepts.

Attitude

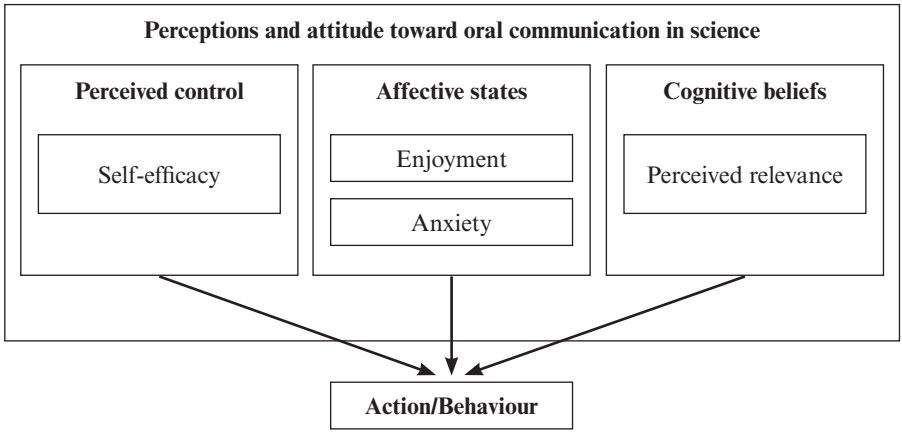
Although the model's title contains two concepts, perceptions and attitude, attitude is the central concept in this research. The term perception is used only to remind us that this is a model focusing on students and their perceptions of OCS.

The concept of attitude is multidimensional, and in essence is highly complex (Ajzen, 2001; Viau et al., 2004), with the result that few studies define it in a comprehensive way. As Osborne et al. (2003) and Venturini (2007) have done in the sciences, this concept is favoured over the concepts of motivation or interest, since attitude is more encompassing and composed of several constructs, including SE, anxiety, enjoyment, and perceived relevance (Bodie, 2010; De Grez et al., 2009; Demir, 2017; Eccles and Wigfield, 2002; McCroskey, 2009). That said, Potvin and Hasni (2014) point out the semantic proximity of these constructs.

The model developed in the present study partly follows the theoretical framework of van Aalderen-Smeets et al. (2012) on teachers' attitude toward science teaching, but is adapted to the context of oral

communication in science. Our model proposes the same four main dimensions as the theoretical framework of van Aalderen-Smeets et al. (2012), namely 1) perceived control, 2) affective state, 3) the cognitive beliefs dimension, and 4) the behavioural dimension identified by the action. However, three of the components in their model (gender beliefs, perceived difficulty, and context dependency) were not included in our adaptation of the model, as only the components most relevant to perceptions and attitude toward OCS were retained. Further research could refine the model, but it is an interesting starting point for studying attitude toward OCS in a more comprehensive way.

Figure 1
Proposal of a theoretical model of perceptions and attitude toward oral communication in science (adapted from van Aalderen-Smeets et al., 2012)



As shown in Figure 1, the theoretical model for perceptions of and attitude toward oral communication in science has four dimensions: 1) perceived control (evaluation based on SE_{OCS}), 2) affective state (evaluation based on anxiety and enjoyment), 3) cognitive beliefs (evaluation based on perceived relevance) and 4) action (behaviour).

Perceived control

This refers to the degree of control a student believes he or she has over the course of an OCS-related activity and the outcomes that will result from it (van Aalderen-Smeets & Walma van der Molen, 2013; Viau, 2009). The evaluation of this dimension is based on self-efficacy in public speaking.

Affective States

This includes the positive and negative emotions the student associates with the OCS. Although this dimension is composed of both enjoyment and anxiety, these two concepts are not two ends of a single scale (Dewaele & MacIntyre, 2014; van Aalderen-Smeets & Walma van der Molen, 2013). For example, a student may enjoy giving an oral presentation, but be nervous during the presentation itself.

Cognitive beliefs

These are the student's cognitive beliefs regarding the OCS. The relevance that the student attributes to the OCS is used to evaluate cognitive beliefs. Perceived relevance includes both the perceived importance and perceived usefulness of the activity (Eccles & Wigfield, 2002; Viau, 2009).

Action

The perceptions and attitude toward OCS lead to the behavioural dimension of the model, i.e., the actions taken by the student in conjunction with an oral presentation. All these actions, whether taken in preparation for or during the oral presentation, facilitate the observation of behaviour, namely, the student's *performance* and level of engagement with the task (Corriveau and Langlois, 2011; Fredricks et al., 2004). Since this last dimension requires a specific type of data collection and a research method different from those employed in the present article, it has been covered in a separate publication (Cormier & Langlois, 2022).

Self-efficacy (perceived control dimension)

Rooted in Bandura's (1977) social cognitive theory, self-efficacy (SE) is based on "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). SE is not a stable personal characteristic, but rather a belief that develops based on lived experiences and varies depending on the task at hand (Bursal, 2012; Choi, 2003).

According to Galand and Vanlede (2004), SE plays a crucial role in motivating people to engage in a task and is a major contributor to performance, regardless of the individual's actual abilities. For example, low SE can lead to disengagement from the task among certain individuals who tend to harbour negative thoughts about their inability to succeed, to the point of believing that there is no point in seeking solutions to improve. This self-perception causes stress and causes them to adopt avoidance behaviours toward the activity (Bouffard-Bouchard and Pinard, 1988).

In an individual, the SE is based on four factors that underlie or modify it, as described by Bandura (1986):

Experience or enactive attainment

This occurs when the individual experiences success in a task. The experience of active mastery reinforces the SE.

Modeling or vicarious experience

This is based on observing a peer succeed or fail at a task. It can help to strengthen or weaken the observer's confidence in his or her own ability to succeed at the task and thus modify the SE.

Social persuasion

This is operationalized when individuals receive feedback (e.g., suggestions, warnings, recommendations) that may give them confidence in their ability to succeed at a task. Since this factor is not based, as are the first two, on experience, it has less of an effect on SE, but can still influence it.

Physiological factors

These are the states that an individual may experience at the thought of performing a task and that may have an effect on their confidence to perform it successfully. In particular, these include physical symptoms of stress, which may be perceived as a sign that the task will not be completed successfully, thereby significantly reducing the SE.

Within a framework of oral communication, experience-related factors (active mastery experience and vicarious experience), verbal persuasion and physiological states can be experienced in a school setting, at least when oral presentations are part of the pedagogical sequence. For example, students may have a vicarious experience when listening to their

classmates' oral presentations or have their SE_{OCS} reinforced by verbal persuasion received in the form of feedback from their colleagues or the teacher (Paradewari, 2017).

To develop their SE_{OCS}, individuals draw on these experiences, but since oral presentations are not widely practiced at the college level (Blanchet et al., 2017), students may lack opportunities to reinforce their SE. They must therefore refer to experiences from earlier in their academic career, without a recent referent that would allow them to update their SE. Even when an individual has rarely made oral presentations, these symptoms are often very strongly anchored in their memory and contribute to weakening their SE.

On the whole, while this research did not specifically address the distinction between the different factors that influence students' SE, it can certainly be argued that these factors, as described by Bandura, are particularly important in understanding SE.

Little research has been carried out on SE (Amirian and Tavakoli, 2016). Demir (2017) indicates that SE decreases continuously between grades 5 and 8. In a study of 200 oral presentations, De Grez et al (2009) demonstrated that SE_{OCS} is the best predictor of oral performance. Other researchers drew similar conclusions when they noted that, of the personal factors measured, only SE was correlated with the final grade in a speaking course (Dwyer & Fus, 2002). These researchers also reported that increases in SE and students' feelings of oral proficiency were related to decreases in speaking apprehension.

Anxiety (affective state dimension)

Since SE also affects emotions, it can influence the stress and anxiety experienced while facing the prospect of performing a task (Dwyer & Fus, 2002). Indeed, a fundamental characteristic of speaking in front of a group is its anxiety-provoking nature.

Most people experience this (McCroskey, 2009) and the main source of "public speaking anxiety" or glossophobia is the fear of being judged negatively by the audience (Schlenker and Leary, 1982). It is characterized by physiological effects (e.g., increased heart rate), negative cognitive effects (e.g., difficulty concentrating while speaking) and behavioural effects (e.g., trembling and blushing) (Bodie, 2010).

Chesebro et al (1992) suggest that audience-based speaking anxiety may be an aggravating factor in poor speaking skills. Thus, students who fear public speaking situations have a tendency to adopt avoidance behaviours, which may magnify their already weak feelings of competence, to the point of obscuring their real competence. By contrast, students who believe they can perform well in public speaking generally experience less anxiety than those who believe they will fail (Lucchetti et al., 2003).

Chesebro et al (1992) also demonstrate that, among secondary school students, anxiety about public speaking is correlated with a greater risk of academic failure and dropping out. Students who are less successful in school often have accumulated experiences of failure in oral presentations, experience overall academic difficulties, or have an overall lack of confidence in their ability to succeed in school.

Enjoyment (affective state dimension)

The concept of enjoyment is semantically similar to the affective aspect of interest (Hidi and Renninger, 2006; Potvin and Hasni, 2014) and to the concept of the positive affective state as used by Ng et al. (2012).

The concept of enjoyment in a public speaking context is not defined in the research literature. However, it is often used in specific fields of study, namely, science teaching (van Aalderen-Smeets et al., 2012), the sciences (Ainley and Ainley, 2011; Potvin and Hasni, 2014) or during oral communication carried out in second language learning (Batenburg et al., 2019).

As stated by several of these researchers, enjoyment, which refers to a positive feeling at the prospect of giving an oral presentation (van Aalderen-Smeets et al., 2012), is closely related to a task; that is to say, enjoyment develops 'for something' (Krapp and Prenzel, 2011; Renninger and Hidi, 2011). This pleasure emerges and increases during the time spent on the task or with the proposed subject (Hidi and Renninger, 2006).

At least in the context of second language learning, enjoyment experienced during oral communication does not appear to be a predictor of performance-related predictor (Batenburg et al., 2019). On the other hand, Boudreau et al. (2018) confirm a relationship between enjoyment and anxiety during public speaking. Moreover, they indicate that this

relationship fluctuates rapidly during oral communication. The cases studied by these researchers indicate that there can be both positive and negative correlations between these two affective states.

Perceived relevance (cognitive beliefs dimension)

The relevance that a student attributes to the OCS refers both to the overall importance that the student attributes to this task in the sciences (Eccles & Wigfield, 2002) and to the perceived usefulness that the student sees for his or her personal future (Viau, 2009). In this regard, Leggett et al (2004) report that university students in the sciences do not appear to be aware of the importance of oral communication skills to their future work in the sciences. These findings are of concern as this skill is desired by many employers and is now prescribed in many science programs around the world (Australian Qualifications Framework, 2013; MELS, 1998; Mercer-Mapstone & Kuchel, 2015).

In one of the few studies on the subject, Edmondston et al (2010) demonstrate that university undergraduates place little value on oral presentations given by non-scientists, do not value training in the communication of science, and have very little knowledge of what constitutes oral communication in science.

Method

Approach of the theoretical model

The Perceptions of and Attitudes toward Oral Communication in the Sciences (PAOCS) questionnaire is derived from the theoretical model presented above. The process of developing its scale was carried out following the seven-step procedure proposed by Dussault et al (2007) and used by Gaudreau et al (2015) in a similar context (the SE). These steps are presented in Table 1 and described in greater detail in the remainder of the paper.

Table 1
Steps in the development of the PAOCS questionnaire (Dussault et al., 2007)

Development stage	Description
1. Choice of constructs to be measured	Using personal factors that may influence attitude and self-perception in public speaking; as based on the research literature.
2. Creation of an item bank	Adapted from items already published in various questionnaires.
3. Choice of format	Four-point Likert scale, since it measures a perception. The aim is to find out whether the student "agrees" or "disagrees" with the item.
4. Evaluation of items by experts	Carried out by 3 college science teachers and 1 college French teacher, all researchers in the field of education.
5. Pre-test	Principal component analysis carried out on 131 students from the same population as the target population test.
6. Test with the target population	n = 1382 students
7. Verification of the the factorial structure	Using a principal component analysis (PCA) and then a confirmatory factor analysis (CFA).

Participants

The participants in this research were postsecondary students (normally around 17-18 years old) enrolled in a pre-university two-year science program. Two samples were drawn: one for step 5 ("pre-test") and one for step 6 ("test with the target population").

Sample and data collection method for the pre-test

The pre-test sample consisted of 131 students, all of whom were enrolled in the first year of the Science program at the same Montreal-area CEGEP (*collège d'enseignement général et professionnel*, known in English as a general and vocational college) at the time of their participation (winter semester of 2018).

The information and consent forms, as well as the questionnaires, were distributed to the students in class by the course teacher, who was not part of the research team. Students who chose to complete the questionnaire did so directly in class. All questionnaires (both those completed and those

left blank) were then placed by the students in an envelope, which was sealed by the last student, so that the teacher could not see the completed questionnaires. All envelopes were then sent to the research team.

Sample and data collection method for the test

The sample for the test with the target population consisted of 1295 students, all enrolled in the first year of the Natural Sciences program, in seven CEGEPs located in the Montreal and Montérégie regions at the time of their participation (autumn semester 2018). The data collection procedure was the same as that described above for the pre-test.

Ethical considerations

Before recruiting began, the research project was approved by the research ethics boards of all the CEGEPs from which the participants were drawn.

Data entry

Data entry was carried out by research assistants. Then, 10% of all the questionnaires (randomly selected) were re-entered and compared to the first entry. This check ensured the accuracy of the data entry.

General description of the questionnaire

Step 1: Choice of constructs to be measured

The questionnaire distributed to the students included:

- socio-demographic questions (age, gender, mother tongue, etc.) ;
- descriptive questions to record students' experiences in academic and extracurricular oral communication;
- four-point Likert scale items on Oral Communication in General (OCG) and Oral Communication in Science (OCS).

The PAOCS scale refers specifically to items about OCS. In the questionnaire, the two types of oral communication were defined for the benefit of students:

1. Oral Communication in General (OCG) refers to a formal oral presentation on a non-scientific topic. It involves non-verbal attitudes, tone and speaking in front of a group;

2. Oral Communication in Science (OCS) refers to a formal oral presentation on a scientific topic or topics. The presentation may use science-specific presentation standards (scientific method). OCS, too, involves non-verbal attitudes, tone and speaking in front of a group.

Each OCG item was paired with an equivalent OCS item. The present paper will present only the results obtained from the PAOCS scale.

Step 2: Creating an item bank

The full set of PAOCS items is presented in the Appendices (Table 5). These items were written in French by the research team and translated in English in the Appendices. Some were inspired by items drawn from the research literature and adapted to the OCS context (Cameron and Dickfos, 2014; Demir, 2017; Hasni et al., 2015; Simpkins et al., 2006; van Aalderen-Smeets and Walma van der Molen, 2013), while others were specifically designed to cover the concepts defined in our theoretical framework. Specifically,

- **SE_{OCS}:** Some of the items were inspired in part by the questionnaires developed by Cameron and Dickfos (2014) and Demir (2017), while the others were developed by the research team. An example of an item for this variable would be: "*When I provide a scientific explanation, people understand it right away*";
- **Enjoyment:** The items were taken and adapted from the questionnaire developed by van Aalderen-Smeets and Walma van der Molen (2013) or from questions stemming from the affective component of interest by Hasni et al. (2015). An example of an item for this variable would be: "*I really enjoy the experience of giving an oral presentation in science*".
- **Anxiety:** The items are taken from an adapted version of the questionnaire by van Aalderen-Smeets and Walma van der Molen (2013). An example of an item for this variable would be: "*I feel nervous during an oral presentation in science*".
- **Perceived relevance:** The items are taken from an adaptation of the Simpkins et al (2006) questionnaire and are supplemented by questions developed by the research team. An example of an item for this variable would be: "*I feel that effective oral communication in science is important*".

The sources of each item as well as the wording of the original item, where relevant, are presented in the Appendices (Table 5). Since none of the items have been kept in their original form (among other things, because they are adapted to an OSC context), a reverse translation for the French version of this article was not required.

Step 3: Choice of format

The declarative Likert scale was recommended for self-report measurement, including for SE (Bandura, 2006). The choice of a four-point scale is justified when dealing with young participants, as they would not have the capacity to adequately evaluate themselves on a six-point scale, or higher (Smith et al., 2003). Toland and Usher (2016) also demonstrate that, compared to a scale of six or more points, the four-point scale yields results that are more consistent with the premises of the normal law, at least for U.S. students with an average age of 12.2 years (grades 6, 7, and 8). Although our participants were predominantly 17-18 years old, we prefer to be cautious and follow the recommendations of these studies. In this type of scale, it also seems desirable to eliminate the "neutral" value that a five-point scale permits, as it may act as a kind of "safe haven" (Smith et al., 2003).

Step 4: Expert evaluation of the items

The 41 selected and adapted items were reviewed by three college science teachers and one French teacher for evidence of content validity, relevance (with respect to the scale with which they were associated) and wording (clarity). Of this analysis, two items were modified for clarity, and one was added ad hoc, given the small number of items for the perceived relevance scale.

An initial test took place in the winter of 2018 to identify the constructs measured by this varied set of items.

Step 5: Pre-test (first phase of development)

During the development phase, a preliminary version of the PAOCS with 42 four-point Likert scale items was distributed to 131 Quebec postsecondary students enrolled in the Natural Sciences program (mean age: 17.9 years; standard deviation: 1.0 years; 54 boys and 72 girls). The data appeared suitable for carrying out exploratory analysis using the principal components analysis (PCA) method [KMO index = 0.889 and Bartlett's test $\chi^2(496) = 3011$; $p < 0.001$] (Tabachnick & Fidell, 2019).

Carried out using SPSS software, the PCA indicated that our items tended to cluster into five or six components, as based on the scree test from the collapse plot. The six-component model was quickly discarded, as the sixth component contained only two items.

In the end, 10 items were removed from the preliminary five-component model, and this was for two reasons: either they appeared with a loading of more than 0.3 in more than one component (Field, 2017), or they were not unequivocal. As presented in Table 2, the selected model therefore contains 32 items distributed over five components, for a total explained variance of 64.2%.

Table 2

Components obtained following the PCA of the preliminary version of the PAOCS (the final 32-item model) with factor loading and internal consistency (reliability) for each component

Component	Description of the component's significance	No. of items	Factor loading	α
Perceived relevance	I find it important to communicate orally effectively.	5	0.62-0.79	0.812
Enjoyment	I enjoy communicating orally.	10	0.62-0.86	0.746
Anxiety	Communicating orally makes me anxious.	4	0.78-0.88	0.924
Norms & Content SE_{OCS}	I express myself well. I have the required level of scientific vocabulary	9	0.51-0.75	0.866
Showmanship SE_{OCS}	I'm interesting when I communicate orally.	4	0.45-0.63	0.648

Note. n = 131.

The high Cronbach's alpha (α) values ensure the internal consistency (or reliability) of each of the component scales as they all exceed the accepted threshold of 0.7, except for the Showmanship SE_{OCS} scale (Nunnally, 1978). Factor loading is acceptable for all scales, as they exceed 0.3 (Field, 2017).

In this preliminary version, items associated with enjoyment (van Aalderen-Smeets & Walma van der Molen, 2013), and with the affective component of interest (Hasni et al., 2015), for oral communication, are

grouped together, as intended, into a single component, which seems to confirm the choice of the "enjoyment" label in the theoretical model for this component. Surprisingly, the SE_{OCS}, seems to be broken down into two components, namely, the Showmanship SE_{OCS} ("*The audience finds my presentations interesting*") and the Norms & Content SE_{OCS} ("*I follow the norms specific to oral communication*"). This separation of oral SE_{OCS} into two distinct components appears to be new in the research literature. It seemed relevant to retain this preliminary result, and to attempt to replicate it, along with the main data collection, since the hitherto monolithic component of SE_{OCS} could perhaps be analyzed in greater detail by considering these two aspects.

Results

Steps 6 and 7: Testing on the target population and verifying the factor structure (second phase of development)

A second version of the PAOCS was prepared for administration to a larger sample. Seven items were added in order to enrich the five components obtained in the preliminary questionnaire: perceived relevance (1), enjoyment (3), anxiety (1), Showmanship SE_{OCS} (1) and Norms & Content SE_{OCS} (1). One item was also re-written since it may not have been unequivocal.

This second version of the 39-item PAOCS was administered to 1314 students from the same population (mean age: 17.3 years; standard deviation: 1.7 years; 737 girls and 524 boys) in the autumn of 2018 at seven CEGEPs. Of the 1314 PAOCS questionnaires received, 19 were incomplete. The rate of missing data was 1.5% (n_{final} = 1295). A sub-sample of approximately 10% (n = 133) was randomly drawn from this data in order to perform a principal component analysis. The data from this sub-sample demonstrated excellent suitability for producing a PCA [KMO index = 0.964 and Bartlett's test = $\chi^2(496) = 2528$; $p < 0.001$].

After observing that models between one and four components were inconclusive (between 34% and 57% of the explained variance), the PCA models indicated that our items again tended to cluster into five components (60.5% of the explained variance) or six components (63.7% of explained variance), when based on the scree test. Since the sixth

component of the second model consisted of only two items, and as this component was conceptually difficult to label, it was decided not to retain this model.

The PCA (see Table 3) made it possible to extract a final model with five components and 34 items, for a percentage of explained variance of 60.5%. The choice to retain this model consequently led to the removal of five items from the questionnaire (numbered and available in the Appendices, Table 6):

- three items with factor loadings of 0.3 in at least two components (items no. 1, 2 and 3) (Field, 2017);
- one item with no factor loadings above 0.3 (item no. 4) (Field, 2017); and
- one item that was not unequivocal (item no. 5). For this item ("*Oral communication in the sciences is dull/uninteresting /boring*"), the likely ambiguity would stem from the fact that students could understand being asked whether they find listening to or giving oral presentations boring.

The five selected components had good internal consistency (α = 0.772-0.951). The level of internal consistency for each of the components was of the same order of magnitude as in the preliminary version, with a significant improvement for the Showmanship SE_{OCS} component. The final model thus allows us to verify that the 34 remaining items behave in much the same way as in the preliminary version of PA_{OCS}.

A confirmatory factor analysis (CFA) with the maximum likelihood method was then carried out using R software (version 3.6.1) on the 34 items from the PCA. A five-factor correlated model was tested on the remaining 90% of the sample (n = 1162). The correlation tables (Tables 7 to 11 in the Appendices) for each of the factors show consistently significant inter-item correlations. A table of factor loadings for the items is also available in the Appendices (Table 6).

The model has acceptable indices of fit. The Root Mean Square Error of Approximation (RMSEA) with a 90% confidence interval is $0.047 \in [0.045; 0.05]$. The upper bound of the RMSEA interval meets the acceptability threshold of the Bentler (2006) and Browne & Cudeck (1992) criterion, which specifies that the upper bound should be >0.08 for an acceptable fit, and <0.05 for a good fit. The Comparative Fit Index (CFI)

Table 3
Components and items selected following the PCA of the final version of the PAOCS, with factor loading and internal consistency for each component

Component label	No. of items	Item's keywords	Factor loading	Cronbach's α
Perceived relevance	5	Significant, useful, work	0.44-0.75	0.772
Enjoyment	11	Enjoyment, enthusiastic, I like it	0.61-0.83	0.951
Anxiety	5	Stressed, nervous, tense	0.62-0.85	0.909
Norms & Content SE_{OCS}	8	Vocabulary, with a clear unifying thread	0.64-0.71	0.836
Showmanship SE_{OCS}	5	Dynamic, attention-grabbing, interest-generating	0.46-0.78	0.865

Note. n = 133
The factor loading for all the items of the 5 components is significant ($p < 0,05$).

is 0.944, which is very close to the good fit threshold of 0.95 proposed by Hu and Bentler (1999). The Standardized Root Mean Square Residual (SRMR) index is 0.05, which is lower than the value of 0.08 considered a good fit by Hu and Bentler (1999).

A conceptual analysis of the items that make up each factor confirms the label for each factor. The factors of anxiety, enjoyment and perceived relevance were expected, corresponding to the factors for which these items had been developed in the research literature from which they were drawn.

Enjoyment and anxiety

These factors were measured with items that read, for example, as follows: "I enjoy making oral presentations in my science classes" (enjoyment factor) or "*I feel stressed when I make an oral presentation in science*" (anxiety factor).

Perceived relevance

This factor contains items that address the perceived usefulness to students of oral communication in science, for example:

"*In general, learning about how to conduct effective oral communication in science is useful*", or about the importance to students of effective oral communication, for example: "*I feel it is important to do well in oral communication in science*". These two aspects seem to reflect two distinct

constructs. This may be the reason why the internal consistency index of the PCA is somewhat lower (α = 0.772) than that of the other factors, though this index is acceptable (Nunnally, 1978).

Two facets of SE_{OCS} emerged from the analysis of the PAOCS data: Norms & Content SE_{OCS} and Showmanship SE_{OCS}. While both do reflect students' self-efficacy, each facet seems to emphasize different aspects of it:

- **Norms & Content SE_{OCS}:** This refers to normative self-efficacy, namely, successful oral communication by expressing oneself well and clearly, respecting norms and ensuring that the audience understands;
- **Showmanship SE_{OCS}:** This refers to the interest in oral communication and performance (being interesting, being dynamic and having good contact with the audience).

The five PAOCS constructs, including the two constructs specific to SE_{OCS}, were ranked on a scale from 1 ("strongly disagree") to 4 ("strongly agree"). An average was then calculated among all PAOCS respondents. These averages are presented in Table 4. The table of correlations between the factors can be found in the Appendices (Table 12).

The lowest mean score of the five scales was for enjoyment (M = 2.11; SD = 0.59), while the highest was for perceived relevance (M = 3.19; SD = 0.56). Between these two values, the mean score was 2.90 (SD = 0.44) for the Norms & Content SE_{OCS}, 2.65 (SD = 0.66) for the Showmanship SE_{OCS} and 2.68 (SD = 0.55) for anxiety. Thus, only the rating for perceived relevance was above the "agree" scale (3), the other four being between "disagree" (2) and "agree" (3). As expected, anxiety correlated negatively with the other four factors.

Table 4
Descriptive scores of the five PAOCS scales for 1295 pre-university students aged 17-18 in the natural sciences

Scale	Mean	Standard deviation	Min.	Max.
Perceived relevance	3.19	0.56	1.00	4.00
Enjoyment	2.11	0.59	1.00	3.83
Anxiety	2.68	0.55æ	1.00	4.00
Norms & Content SE_{OCS}	2.90	0.44	1.22	4.00
Showmanship SE_{OCS}	2.65	0.66	1.00	4.00

Discussion

We continue with a discussion on the link between the two aspects of SE_{OCS} in Bandura's (1977) conceptual framework, and on the validation process for the PAOCS questionnaire scales. We then conclude with a comparison between the theoretical model initially presented and the factors included in the final PAOCS scale.

SE_{OCS} and Bandura's conceptual framework

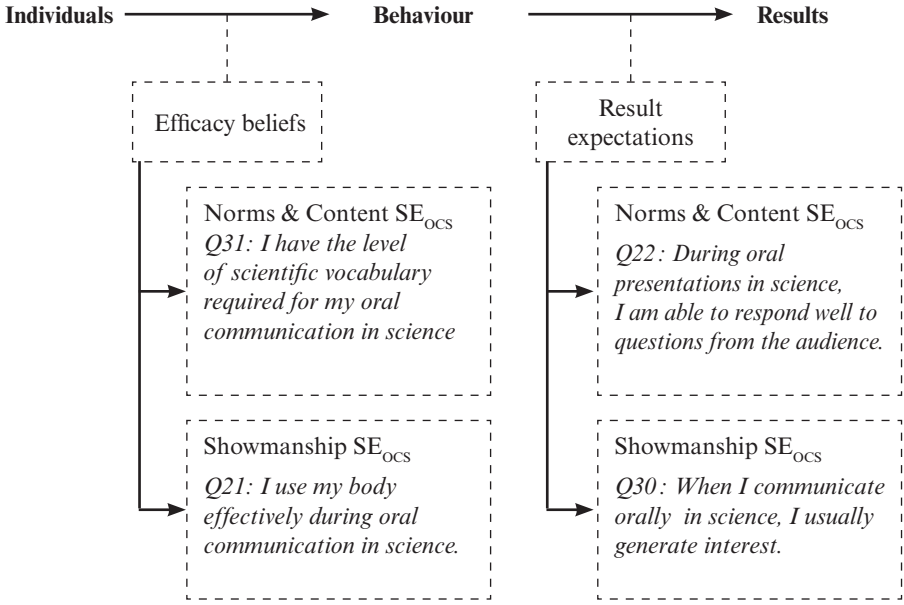
The two SE_{OCS} aspects entitled "Norms & Content" and "Showmanship" constitute a previously unknown observation in the SE research literature. Deriving from four sources (active mastery experience, vicarious experience, verbal persuasion, and physiological and emotional states), SE is generally perceived as a single construct (it is not defined using a factorial structure that breaks down into multiple principal components) and is studied as such (Chan, 2011; De Grez et al., 2009; Demir, 2017).

Nevertheless, a conceptual consistency can be observed in distinguishing between the two blocks of items that form these two constructs: Norms & Content SE_{OCS} refers to the perception of being effective in speaking and expressing oneself well, whereas Showmanship SE_{OCS} refers to the perception of being interesting and dynamic, of being able to capture the attention of the audience.

Returning to Bandura's (1977) conceptual framework, this division of SE into two aspects suggests that students may have efficacy beliefs that are distinct from their outcome expectations regarding both aspects of SE_{OCS}. These two types of expectations are described by Bandura (1986) as the "[capability] to organize and execute courses of action required to attain designated types of performances. " (p. 391). An example of the item for each type of expectation in relation to the SE aspect is provided in Figure 2.

Figure 2

Adaptation of Bandura's (1977) diagram of the difference between efficacy beliefs and outcome expectancies in the case of oral communication in science



Efficacy beliefs

Efficacy beliefs for Norms & Content SE_{ocs} are characterized by the student's belief that he or she has the scientific knowledge and language level required to perform the task well. For Showmanship SE_{ocs}, they are related to the student's belief that he or she will be able to use their body effectively or that they will be dynamic during the oral presentation.

Result expectations

For Norms & Content SE_{ocs}, outcome expectancies refer to the student's ability to answer questions from the audience and to provide the audience with an understanding of the content. For Showmanship SE_{ocs}, result expectations relate to the student's belief that the "Showmanship" (the performance) they produce will capture the attention or interest of the audience.

Process of validation of the PAOCS internal structure

One objective of the present study was to carry out a process for validation of the PAOCS scale by following the procedure proposed by Dussault et al. (2007) and used by Gaudreau et al. (2015). The overall evaluation of the PAOCS shows that the questionnaire has good psychometric qualities (acceptable Cronbach alphas, suitable factor loadings, etc.). Moreover, the distribution of items within each of the factors is produced according to theoretical expectations. Thus, it appears that some or all of the measurement scales can be used with some degree of confidence for research purposes. Certain factors do not have a large number of items. However, given the high percentages of total explained variance and the joint presence of a large number of measured constructs (five constructs for 34 items in total), this can be viewed more as a strength.

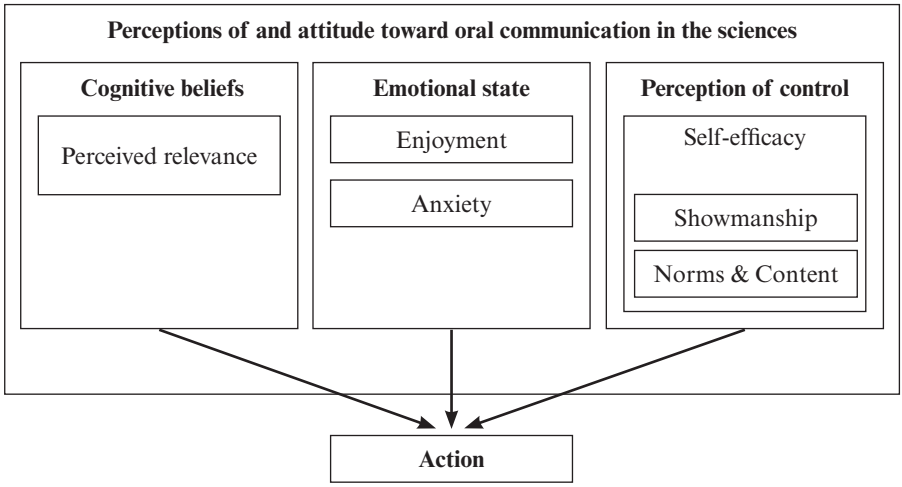
Limits

However, certain common limitations must be considered following the development of the PAOCS questionnaire. First, the selected sample came from public colleges in the greater Montreal area. It did not represent all colleges in the province (other regions and private colleges). No study has yet been conducted to extend the use of the PAOCS to other school contexts or to a sample of younger or older participants. Furthermore, the sample is one of convenience, as it is composed of voluntary participants. Finally, the principal component analysis and the confirmatory factor analysis would have greater value if they were conducted on samples from independent data collections (Thompson, 2004).

Correspondence between the theoretical model and the analyses performed (adding the two aspects of the SE_{OCS})

With the exception of the SE_{OCS}, which henceforth was divided into two aspects, the initial theoretical model seemed to be largely confirmed by this exercise.

Figure 3
Proposed modifications to the theoretical model of perceptions of and attitudes toward oral communication in the sciences



Limitations

The model presented in Figure 3 has a number of limitations. Like the model proposed by van Aalderen-Smeets and Walma van der Molen (2013), the labels associated with attitude dimensions (cognitive beliefs, affective state and perceived control) are based on theoretical considerations and have not been empirically verified. In order to fully validate this model, future research would need to address this consideration. Similarly, it would be relevant to try to include the other components of van Aalderen-Smeets and Walma van der Molen's (2013) model that were excluded from the present study, namely, perceived difficulty, gender stereotypes and context dependency.

In addition, the behaviour dimension (action) was not validated in this paper. Thus, it is not possible to know whether the students' perceptions of and attitudes toward oral communication in the sciences translated into a high level of engagement in the preparation and delivery of oral presentations. This theoretical model would also be worth using in the context of evaluating the behavioural dimension (action), i.e., the actual OCS competence of the student.

Further research is required on the alignment between the two components of the SE_{OCS} and Bandura's (1977) chart on efficacy beliefs and result expectations. Although our interpretation suggests some consistency with Bandura's (1977) framework, it would be desirable to have a more exhaustive questionnaire focusing solely on Norms & Content SE_{ocs} and Showmanship SE_{ocs}, which would attempt to factorially produce both types of expectations for each of the two SE_{OCS}.

Finally, some studies demonstrate that self-efficacy is the factor that seems to most strongly influence performance in oral communication in front of an audience (Dwyer & Fus, 2002). Since our results suggest that there are two aspects to SE_{OCS}, it seems appropriate to investigate the relationship between speaking ability and each of these SE_{OCS} aspects. More generally, it is worth asking which of the five factors in the model is the best predictor of competence.

Reception: March 31, 2020
Final version: December 22, 2021
Acceptance: January 7 2022

REFERENCES

Ainley, M., & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology*, *36*(1), 4-12. https://doi.org/10.1016/j.cedpsych.2010.08.001

Ajzen, I. (2001). Nature and operation of attitudes. *Annual Review of Psychology*, *52*(1), 27-58. https://doi.org/10.1146/annurev.psych.52.1.27

Amirian, S. M. R., & Tavakoli, E. (2016). Academic oral presentation self-efficacy: A cross-sectional interdisciplinary comparative study. *Higher Education Research & Development*, *35*(6), 1095-1110. https://doi.org/10.1080/07294360.2016.1160874

Australian Qualifications Framework. (2013). *AQF specification for the Master's Degree*. Australian Government. http://www.aqf.edu.au

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215. https://doi.org/10.1037//0033-295x.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman/Times Books/Henry Holt & Co.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan, *Self-efficacy beliefs of adolescents* (Vol. 5, p. 307-337). Information Age Publishing.

Barmby, P., Kind, P. M., & Jones, K. (2008). Examining changing attitudes in secondary school science. *International Journal of Science Education*, *30*(8), 1075-1093. https://doi.org/10.1080/09500690701344966

Batenburg, E. S. L. V., Oostdam, R. J., Gelderen, A. J. S. V., Fukkink, R. G., & Jong, N. H. D. (2019). Oral interaction in the EFL classroom: The effects of instructional focus and task type on learner affect. *The Modern Language Journal*, *103*(1), 308-326. https://doi.org/10.1111/modl.12545

Bentler, P. M. (2006). *EQS Structural Equations Program Manual* (version 6) [Software]. Multivariable Software, Inc.

Blanchet, P.-A., Lison, C. & Lépine, M. (2017). L'enseignement de la compétence orale dans les cours de français du collégial : quels choix de contenus ? Dans C. Dumais, R. Bergeron & C. Lavoie (eds.), *L'oral et son enseignement: pluralité des contextes linguistiques* (p. 103-125). Peisaj.

Bodie, G. D. (2010). A racing heart, rattling knees, and ruminative thoughts: Defining, explaining, and treating public speaking anxiety. *Communication Education*, *59*(1), 70-105. https://doi.org/10.1080/03634520903443849

Boudreau, C., MacIntyre, P. D., & Dewaele, J.-M. (2018). Enjoyment and anxiety in second language communication: An idiodynamic approach. *Studies in Second Language Learning and Teaching*, *8*(1), 149. http://dx.doi.org/10.14746/ssllt.2018.8.1.7

Bouffard-Bouchard, T. & Pinard, A. (1988). Sentiment d'auto-efficacité et exercice des processus d'autorégulation chez des étudiants de niveau collégial. *International Journal of Psychology*, *23*(1-6), 409-431. https://doi.org/10.1080/00207598808247776

Brewer, C. A., & Smith, D. (2009). *Vision and change in undergraduate biology education: A call to action* [Final report of national conference]. American Association for the Advancement of Science.

Browne, M. W., & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, *21*(2), 230-258. https://doi.org/10.1177/0049124192021002005

Bursal, M. (2012). Changes in American preservice elementary teachers' efficacy beliefs and anxieties during a science methods course. *Science Education International*, *23*(1), 40-55. https://files.eric.ed.gov/fulltext/EJ975549.pdf

Cameron, C., & Dickfos, J. (2014). ''Lights, camera, action!'' Video technology and students' perceptions of oral communication in accounting education. *Accounting Education*, *23*(2), 135-154. https://doi.org/10.1080/09639284.2013.847326

Casner-Lotto, J., & Barrington, L. (2006). *Are they really ready to work? Employers perspectives on the basic knowledge and applied skills of new entrants to the 21st century U.S. workforce*. Partnership for 21st Century Skills. https://eric.ed.gov/?id=ED519465

Chan, V. (2011). Teaching oral communication in undergraduate science: Are we doing enough and doing it right? *Journal of Learning Design*, *4*(3), 71-79. https://files.eric.ed.gov/fulltext/EJ940652.pdf

Chesebro, J. W., McCroskey, J. C., Atwater, D. F., Bahrenfuss, R. M., Cawelti, G., Gaudino, J. L., & Hodges, H. (1992). Communication apprehension and self-perceived communication competence of at-risk students. *Communication Education*, *41*, 345-360. https://doi.org/10.1080/03634529209378897

Choi, N. G. (2003). Determinants of self-perceived changes in health status among pre- and early-retirement populations. *International Journal of Aging & Human Development*, *56*(3), 197-222. https://doi.org/10.2190/T8JD-1P30-6MFT-8WHA

Cormier, C., & Langlois, S. (2022). Enjoyment and self-efficacy in oral scientific communication are positively correlated to postsecondary students' oral performance skills. *Education Sciences*, *12*(7), 466. https://doi.org/10.3390/educsci12070466

Corriveau, G. & Langlois, S. (2011). Pour un meilleur engagement des garçons et des filles au laboratoire de physique. *Pédagogie collégiale*, *24*(3), 37-44. http://eduq.info/xmlui/handle/11515/21815

De Grez, L., Valcke, M., & Roozen, I. (2009). The impact of goal orientation, self-reflection and personal characteristics on the acquisition of oral presentation skills. *European Journal of Psychology of Education*, *24*(3), 293. https://doi.org/10.1007/BF03174762

Demir, S. (2017). An evaluation of oral language: The relationship between listening, speaking and self-efficacy. *Universal Journal of Educational Research*, *5*(9), 1457-1467. https://doi.org/10.13189/ujer.2017.050903

Dewaele, J.-M., & MacIntyre, P. D. (2014). The two faces of Janus? Anxiety and enjoyment in the foreign language classroom. *Studies in Second Language Learning and Teaching*, *4*(2), 237-274. https://doi.org/10.14746/ssllt.2014.4.2.5

Dumais, C. et Granger, N. (2017). Intégrer l'oral au cours de science et technologie au secondaire. *Spectre*, *46*(2), 26-29. https://www.academia.edu/34793836/ Int %C3 %A9grer_l_oral_au_cours_de_science_et_technologie_au_secondaire

Dunbar, N. E., Brooks, C. F., & Kubicka-Miller, T. (2006). Oral communication skills in higher education: Using a performance-based evaluation rubric to assess communication skills. *Innovative Higher Education*, *31*(2), 115. https://doi.org/10.1007/s10755-006-9012-x

Dussault, M., Valois, P. & Frenette, E. (2007). Validation de l'Échelle de leadership transformatif du directeur d'école. *Psychologie du travail et des organisations*, *13*, 37-52. https://www.researchgate.net/publication/289676242_Validation_de_l'Echelle_de_Leadership_Transformatif_du_Directeur_d'Ecole

Dwyer, K. K., & Fus, D. A. (2002). Perceptions of communication competence, self-efficacy, and trait communication apprehension: Is there an impact on basic course success? *Communication Research Reports*, *19*(1), 29-37. https://doi.org/10.1080/08824090209384829

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*(1), 109-132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Edmondston, J. E., Dawson, V., & Schibeci, R. (2010). Undergraduate biotechnology students' views of science communication. *International Journal of Science Education*, *32*, 2451-2474. https://doi.org/10.1080/09500690903514598

Ellis, K. (1995). Apprehension, self-perceived competency, and teacher immediacy in the laboratory-supported public speaking course: Trends and relationships. *Communication Education*, *44*(1), 64-78. https://doi.org/10.1080/03634529509378998

Field, A. (2017). *Discovering statistics using SPSS: North American edition* (5th ed.). SAGE.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59-109. https://doi.org/10.3102/00346543074001059

Galand, B. & Vanlede, M. (2004). Le sentiment d'efficacité personnelle dans l'apprentissage et la formation: quel rôle joue-t-il? D'où vient-il? Comment intervenir? *Savoirs, hors série*(5), 91-116. https://doi.org/10.3917/savo.hs01.0091

Gaudreau, N., Frenette, E. & Thibodeau, S. (2015). Élaboration de l'Échelle du sentiment d'efficacité personnelle des enseignants en gestion de classe (ÉSEPGC). *Mesure et évaluation en éducation*, *38*(2), 31-60. https://doi.org/10.7202/1036762ar

Hasni, A., Potvin, P., Belletête, V. & Thibault, F. (2015). *L'intérêt pour les sciences et la technologie à l'école : résultats d'une enquête auprès d'élèves du primaire et du secondaire au Québec* [rapport de recherche]. UQAM et Université de Sherbrooke. https://www.usherbrooke.ca/creas/fileadmin/sites/creas/documents/Publications/Productions_internes/Hasni-Potvin-Rapport-CRIJEST-2015-VF.pdf

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111-127. https://doi.org/10.1207/s15326985ep4102_4

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Jones, M. G., & Leagon, M. (2014). Science teacher attitudes and beliefs. In N. Lederman & S. Abell (eds.), *Handbook of research on science education* (Vol. 2, p. 830-843). Routledge.

Kazempour, M. (2014). I can't teach science! A case study of an elementary pre-service teacher's intersection of science experiences, beliefs, attitude, and self-efficacy. *International Journal of Environmental and Science Education*, *9*(1), 77-96. https://doi.org/10.12973/ijese.2014.204a

Kerby, D., & Romine, J. (2009). Develop oral presentation skills through accounting curriculum design and course-embedded assessment. *Journal of Education for Business*, *85*(3), 172-179. https://doi.org/10.1080/08832320903252389

Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education*, *33*(1), 27-50. https://doi.org/10.1080/09500693.2010.518645

Kulgemeyer, C. (2018). Impact of secondary students' content knowledge on their communication skills in science. *International Journal of Science and Mathematics Education*, *16*(1), 89-108. https://doi.org/10.1007/s10763-016-9762-6

Kulgemeyer, C., & Schecker, H. (2013). Students explaining science: Assessment of science communication competence. *Research in Science Education*, *43*(6), 2235-2256. http://dx.doi.org/10.1007/s11165-013-9354-1

Leggett, M., Kinnear, A., Boyce, M., & Bennett, I. (2004). Student and staff perceptions of the importance of generic skills in science. *Higher Education Research & Development*, *23*(3), 295-312. https://doi.org/10.1080/0729436042000235418

Lucchetti, A. E., Phipps, G. L., & Behnke, R. R. (2003). Trait anticipatory public speaking anxiety as a function of self-efficacy expectations and self-handicapping strategies. *Communication Research Reports*, *20*(4), 348-356. https://doi.org/10.1080/08824090309388834

McCroskey, J. C. (2009). Communication apprehension: What have we learned in the last four decades. *Human Communication*, *12*(2), 179-187. https://www.researchgate.net/publication/254840900_Communication_Apprehension_What_Have_We_Learned_in_the_Last_Four_Decades

McLaren, I. (2019). Science students' responses to an oral communication skills development initiative: Attitude and motivation. *International Journal of Teaching and Learning in Higher Education*, *31*(1), 73-85. https://files.eric.ed.gov/fulltext/EJ1206982.pdf

Mercer-Mapstone, L. D., & Kuchel, L. (2015). Teaching scientists to communicate: Evidence-based assessment for undergraduate science education. *International Journal of Science Education*, *37*(10), 1613-1638. https://doi.org/10.1080/09500693.2015.1045959

Mercer-Mapstone, L. D., & Matthews, K. E. (2017). Student perceptions of communication skills in undergraduate science at an Australian research-intensive university. *Assessment & Evaluation in Higher Education*, *42*(1), 98-114. https://doi.org/10.1080/02602938.2015.1084492

Ministère de l'Éducation et de l'Enseignement supérieur (MELS). (1998). *Sciences de la nature (200.B0): programme d'études préuniversitaires – Enseignement collégial*. Gouvernement du Québec. http://www.education.gouv.qc.ca/fileadmin/site_web/documents/enseignement-superieur/200.B0-Sciences-nature-VF.pdf

Mulder, H. A. J., Longnecker, N., & Davis, L. S. (2008). The state of science communication programs at universities around the world. *Science Communication*, *30*(2), 277-287. https://doi.org/10.1177 %2F1075547008324878

Ng, K. T., Lay, Y. F., Areepattamannil, S., Treagust, D. F., & Chandrasegaran, A. L. (2012). Relationship between affect and achievement in science and mathematics in Malaysia and Singapore. *Research in Science & Technological Education*, *30*(3), 225-237. https://doi.org/10.1080/02635143.2012.708655

Nunnally, J. C. (1978). *Psychometric theory*. McGraw-Hill.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Paradewari, D. S. (2017). Investigating students' self-efficacy of public speaking. *International Journal of Education and Research*, *5*(10), 97-108. http://ijern.com/journal/2017/October-2017/09.pdf

Pintrich, P. R., & de Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33-40. https://doi.org/10.1037/0022-0663.82.1.33

Potvin, P., & Hasni, A. (2014). Analysis of the decline in interest towards school science and technology from grades 5 through 11. *Journal of Science Education and Technology*, *23*(6), 784-802. https://doi.org/10.1007/s10956-014-9512-x

Rajput, A. S. D. (2017). Science communication as an academic discipline: An Indian perspective. *Current Science*, *113*(12), 2262-2267. https://www.currentscience.ac.in/Volumes/113/12/2262.pdf

Renninger, K. A., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist*, *46*(3), 168-184. https://doi.org/10.1080/00461520.2011.587723

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education*, *74*(6), 625-637. https://doi.org/10.1002/sce.3730740605

Schlenker, B. R., & Leary, M. R. (1982). Social anxiety and self-presentation: A conceptualization model. *Psychological Bulletin*, *92*(3), 641-669. https://doi.org/10.1037/0033-2909.92.3.641

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70-83. https://doi.org/10.1037/0012-1649.42.1.70

Smith, E. V. Jr., Wakely, M. B., De Kruif, R. E. L., & Swartz, C. W. (2003). Optimizing rating scales for self-efficacy (and other) research. *Educational and Psychological Measurement*, *63*(3), 369-391. https://doi.org/10.1177/0013164403063003002

Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications*. American Psychological Association. https://doi.org/10.1037/10694-000

Toland, M. D., & Usher, E. L. (2016). Assessing mathematics self-efficacy: How many categories do we really need? *The Journal of Early Adolescence*, *36*(7), 932-960. https://doi.org/10.1177/0272431615588952

Tsai, C.-C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education*, *24*(8), 771-783. https://doi.org/10.1080/09500690110049132

van Aalderen-Smeets, S. I., & Walma van der Molen, J. H. (2013). Measuring primary teachers' attitudes toward teaching science: Development of the Dimensions of Attitude Toward Science (DAS) Instrument. *International Journal of Science Education*, *35*(4), 577-600. https://doi.org/10.1080/09500693.2012.755576

van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: A new theoretical framework. *Science Education*, *96*(1), 158-182. https://doi.org/10.1002/sce.20467

Venturini, P. (2007). *L'envie d'apprendre les sciences : motivations, attitudes, rapport aux savoirs scientifiques*. Fabert.

Viau, R. (2009). *La motivation en contexte scolaire* (5th ed.). De Boeck. https://www.deboecksuperieur.com/ouvrage/9782804111489-la-motivation-en-contexte-scolaire

Viau, R., Joly, J. & Bédard, D. (2004). La motivation des étudiants en formation des maîtres à l'égard d'activités pédagogiques innovatrices. *Revue des sciences de l'éducation*, *30*(1), 163-176. https://doi.org/10.7202/011775ar

Zembylas, M. (2002). Constructing genealogies of teachers' emotions in science teaching. *Journal of Research in Science Teaching*, *39*(1), 79-103. https://doi.org/10.1002/tea.10010

Appendices

Table 5
Items and origin of the 34 PAOCS questionnaire

PAOCS questionnaire item	Source from which the item is adapted	Original formulation	Dimension measured based on the source from which it is adapted
Perceived relevance			
Effectiveness in giving oral presentations in science is important to me.	Simpkins et al. (2006)	*For me, being good at (science / physics and chemistry) is (not at all important / very important).*	Perceptions of the importance of science (*Children's perceptions of the importance of science*)
In general, it is useful to learn how to give effective oral presentations in science.	Simpkins et al. (2006)	*In general, how useful is what you learn in (science/physics and chemistry)?*	Perceptions of the importance of science (*Children's perceptions of the importance of science*)
Giving effective oral presentations in science is important to me.	Simpkins et al. (2006)	Compared to most of your other activities, how important is it to you to be good in science?	Perceptions of the importance of science (*Children's perceptions of the importance of science*)
Learning how to give effective oral presentations in science will be relevant to my future work.	Original item	N/A	N/A
Speaking well will give me credibility in my future academic career in science.	Original item	N/A	N/A
Enjoyment			
I really enjoy giving oral presentations in science.	van Aalderen- Smeets et al. (2013)	*I enjoy teaching science very much.*	Enjoyment

PAOCS questionnaire item	Source from which the item is adapted	Original formulation	Dimension measured based on the source from which it is adapted
I am enthusiastic about giving oral presentations in science.	van Aalderen- Smeets et al. (2013)	*Teaching science makes me enthusiastic.*	Enjoyment
I'm happy when I give an oral presentation in science.	van Aalderen- Smeets et al. (2013)	*I feel happy while teaching science.*	Enjoyment
In general, I have a lot of fun giving an oral presentation in a science class.	van Aalderen- Smeets et al. (2013)	*I enjoy teaching science very much.*	Enjoyment
Giving an oral presentation in science makes me happy.	van Aalderen- Smeets et al. (2013)	*Teaching science makes me happy.*	Enjoyment
I look forward to upcoming oral presentations in the sciences.	Hasni et al. (2015)	I look forward to the next ST [Science and Technology] activities.	Interest
Oral communication in science is fun.	Hasni et al. (2015)	ST at school is fun.	Interest
We should spend more time giving oral presentations in my science classes at school.	Hasni et al. (2015)	We should spend more time on ST at school.	Interest
If I had the choice, I would never give oral presentations in my science classes.	Hasni et al. (2015)	If I had the choice. I would not take anymore ST classes.	Interest (negative)
I like to give oral presentations in my science classes.	Original item	N/A	N/A
In general, I like to give oral presentations in science.	Original item	N/A	N/A
Anxiety			
I usually feel stressed when I give an oral presentation in a science class.	van Aalderen- Smeets et al. (2013)	*I feel stressed when I have to teach science in my class.*	Anxiety

PAOCS questionnaire item	Source from which the item is adapted	Original formulation	Dimension measured based on the source from which it is adapted
I feel nervous during an oral presentation in science.	van Aalderen- Smeets et al. (2013)	*I feel nervous while teaching science.*	Anxiety
I feel stressed when I give an oral presentation in science.	van Aalderen- Smeets et al. (2013)	*I feel stressed when I have to teach science in my class.*	Anxiety
Giving an oral presentation in science makes me nervous.	van Aalderen- Smeets et al. (2013)	*I feel nervous while teaching science.*	Anxiety
I feel tense during an oral presentation in science.	van Aalderen- Smeets et al. (2013)	*I feel tense while teaching science in class.*	Anxiety
Norms & Content SE			
During oral presentations in science, I am able to answer audience questions adeptly.	Demir (2017)	*I give accurate answers to the questions directed at me.*	SE in speaking skills
I give clear explanations during my oral presentations in science.	Cameron and Dickfos (2014)	*How confident are you in your ability to present your ideas clearly?*	SE in oral communication
I'm able to present my ideas in a structured way, and establish a clear main thread (or unifying theme), when giving an oral presentation in science.	Cameron and Dickfos (2014)	*How confident are you in your ability to present your ideas in a logical way which the audience can easily follow?*	SE in oral communication
When I give an oral presentation in science. people understand it right away.	Cameron and Dickfos (2014)	*When I give verbal instructions or directions to people. they usually clearly understand ''first time'' what I mean.*	Oral communication skills

PAOCS questionnaire item	Source from which the item is adapted	Original formulation	Dimension measured based on the source from which it is adapted
I have the level of scientific vocabulary required for my oral presentations in science.	Original item	N/A	N/A
In general, I use accurate and precise terms when I communicate orally with my science teachers.	Original item	N/A	N/A
The level of language I employ is appropriate for my oral presentations in science.	Original item	N/A	N/A
I'm well-organized in preparing an oral presentation in science.	Original item	N/A	N/A
Showmanship SE			
I know how to capture the attention of my audience when giving an oral presentation in science.	Cameron and Dickfos (2014)	*How confident are you in your ability to present your ideas in a way that captures the audience's attention?*	SE in oral communication
I usually generate interest in my oral presentations in science.	Cameron and Dickfos (2014)	*When I give a presentation. it seems to stimulate a fair level of interest amongst the listeners.*	Oral communication skills
I use body language effectively during oral presentations in science (posture. movement. etc.).	Cameron and Dickfos (2014) Demir (2017)	*How confident are you in your ability to use appropriate eye contact and body language when presenting your ideas? I use body language effectively in my speech*	SE in oral communication SE in public speaking skills

PAOCS questionnaire item	Source from which the item is adapted	Original formulation	Dimension measured based on the source from which it is adapted
I know how to make good contact with the audience during oral presentations in science.	Cameron and Dickfos (2014)	How confident are you in your ability to use appropriate eye contact and body language when presenting your ideas?	SE in oral communication
I'm dynamic during my oral presentations in science.	Original item	N/A	N/A

Table 6
Results of the principal component analysis (PCA) and confirmatory factor analysis (CFA)

Component	Item	PCA	CFA
Perceived relevance	It's important for me to be good at oral presentations in science.	0.711	0.754
	In general, it is useful to learn how to give effective oral presentations in science.	0.714	0.754
	Giving effective oral presentations in science is important to me.	0.707	0.710
	Learning how to give effective oral presentations in science will be relevant in my future work.	0.636	0.695
	Speaking well gives credibility to my academic career in science.	0.482	0.457
Enjoyment	I really enjoy giving oral presentations in science.	0.834	0.830
	I am enthusiastic about giving oral presentations in science.	0.807	0.825
	I like to give oral presentations in my science classes.	0.833	0.824
	I'm looking forward to upcoming oral presentations in science.	0.819	0.817
	I feel happy when I give an oral presentation in science.	0.836	0.810
	In general, I really enjoy giving an oral presentation in a science class.	0.877	0.808
	Oral communication in science is fun.	0.796	0.795
	In general, I like to give oral presentations in science.	0.802	0.794
	Giving an oral presentation in science makes me happy.	0.823	0.769
	We should spend more time giving oral presentations in my science classes at school.	0.410	0.629
	If I had the choice. I would never give oral presentations in my science classes.	-0.546	-0.569
	(5) Oral presentations in science are boring.		
	(1) I find it easy to give oral presentations in science.		

Component	Item	PCA	CFA
Anxiety	I usually feel stressed when I give an oral presentation in a science class.	0.869	0.850
	I feel nervous during an oral presentation in science.	0.836	0.825
	I feel stressed when giving an oral presentation in science.	0.808	0.816
	Giving an oral presentation in science makes me nervous.	0.785	0.792
	I feel tense when giving oral presentations in science.	0.667	0.629
Norms & Content SE	I have the level of scientific vocabulary required for my oral presentations in science.	0.736	0.768
	In general, I use accurate and precise terms when communicating orally with my science teachers.	0.708	0.755
	The level of language I employ is appropriate for my oral presentations in science.	0.667	0.721
	I provide clear explanations during my oral presentations in science.	0.629	0.625
	I'm able to present my ideas in a structured way, and with a clear common thread (or unifying theme) when I give an oral presentation in science.	0.626	0.604
	During oral presentations in science, I'm adept at answering audience questions	0.644	0.569
	When I give an oral presentation in science, people understand it right away.	0.381	0.557
	I'm well-organized when preparing oral presentations in science.	0.465	0.410
	(2) I can be brief and synthesize information well when giving oral presentations in science.		
	(3) When giving oral presentations in science I respect the allotted speaking time.		
Showmanship SE	I'm dynamic during my oral presentations in science.	0.661	0.698
	I'm good at making contact with the audience during oral presentations in science.	0.629	0.693
	I use body language effectively during oral presentations in science (posture, movement. etc.).	0.666	0.686
	I know how to attract the attention of my audience when giving an oral presentation in science.	0.767	0.686
	When I give an oral presentation in science, I generally create interest in the subject matter.	0.683	0.623
	(4) When giving an oral presentation in science, I am able, if necessary, to use popularization techniques effectively (analogies, comparisons, etc.) to make myself understood.		

Note. Items numbered (1) through (5) have been removed from the scale. This is explained in the text.

Table 7
Inter-item correlation matrices for the perceived relevance factor

	Q1	Q2	Q3	Q4	Q5
Q1					
Q2	0.34***				
Q3	0.40***	0.55***			
Q4	0.55***	0.44***	0.42***		
Q5	0.28***	0.33***	0.30***	0.43***	

*** $p < 0.001$.

Table 8
Inter-item correlation matrices for the enjoyment factor

	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Q6											
Q7	0.53***										
Q8	0.57***	0.76***									
Q9	0.60***	0.69***	0.73***								
Q10	0.54***	0.65***	0.66***	0.70***							
Q11	0.58***	0.67***	0.66***	0.70***	0.67***						
Q12	0.59***	0.69***	0.69***	0.71***	0.68***	0.75***					
Q13	0.57***	0.68***	0.68***	0.71***	0.64***	0.72***	0.75***				
Q14	0.57***	0.69***	0.70***	0.74***	0.71***	0.71***	0.73***	0.73***			
Q15	0.60***	0.71***	0.69***	0.73***	0.72***	0.72***	0.74***	0.72***	0.77***		
Q16	0.54***	0.52***	0.52***	0.56***	0.53***	0.58***	0.56***	0.56***	0.56***	0.60***	

*** $p < 0.001$.

Table 9
Inter-item correlation matrices for the anxiety factor

	Q17	Q18	Q19	Q20	Q21
Q17					
Q18	0.54***				
Q19	0.53***	0.82***			
Q20	0.53***	0.76***	0.73***		
Q21	0.53***	0.71***	0.73***	0.72***	

*** $p < 0.001$.

Table 10
Inter-item correlation matrices for the Norms & Content SE factor

	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29
Q22								
Q23	0.34***							
Q24	0.29***	0.49***						
Q25	0.32***	0.37***	0.30***					
Q26	0.37***	0.36***	0.40***	0.41***				
Q27	0.43***	0.42***	0.44***	0.40***	0.53***			
Q28	0.30***	0.50***	0.51***	0.40***	0.44***	0.44***		
Q29	0.26***	0.33***	0.34***	0.35***	0.42***	0.38***	0.41***	

*** $p < 0.001$.

Table 11
Inter-student correlation matrices for the Showmanship SE factor

	Q30	Q31	Q32	Q33	Q34
Q30					
Q31	0.57***				
Q32	0.47***	0.57***			
Q33	0.50***	0.60***	0.61***		
Q34	0.53***	0.59***	0.56***	0.62***	

*** $p < 0.001$.

Table 12
Correlation matrices of the five PAOCS factors

	Perceived relevance	Enjoyment	Anxiety	Norms & Content SE	Showmanship SE
Perceived relevanc					
Enjoyment	0.41**				
Anxiety	-0.17**	-0.56**			
Norms & Content SE	0.37**	0.35**	-0.29**		
Showmanship SE	0.35**	0.53**	-0.50**	0.56**	

** $p < 0.001$.

The study examined trends and relationships in communication apprehension (CA). self-efficacy (SE), self-perceived public speaking competence (SPPSC), and their impact on course grade, for 304 students enrolled in a basic public speaking course. Respondents completed McCroskey's (1982) Personal Report of Communication Apprehension (PRCA-24). the Self-Efficacy scale (SE Scale) (Pintrich and DeGroot. 1990). and the Self-perceived Public Speaking Competency scale (SPPSC Scale) (Ellis. 1995). The latter scale is based on the National Communication Association's (NCA) "Competent Speaker Speech Evaluation Form" (Morreale. 1990). Results indicated that significant changes occurred in CA, SE, and SPPSC levels throughout the semester. However. only the SE at mid-semester and semester's end predicted the grade.