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The role of feedback in young people's academic choices

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ABSTRACT

Women are underrepresented in Science, Technology, Engineering and Mathematics subjects with more girls leaving these subjects at every stage in education. The current research used a scenario methodology to examine the impact of teacher feedback on girls' and boys' choices to study a specific science subject, engineering. British participants aged 13 ($N = 479$) were given scenarios where a new teacher encouraged them to take engineering using person feedback which focussed on their abilities, process feedback which focussed on their effort levels or gave them no reason. Results suggested that both boys and girls were more likely to select to study engineering when they received person feedback rather than process or no feedback. Young people also thought that ability was more important to being successful in science than in non-science subjects.This suggests young people feel that ability is needed to succeed in science subjects and person feedback can lead them to believe that they have this ability. Therefore, teacher feedback which gives ability attributions for possible success could be used to encourage more young people to persist in science. However, the potentially negative longer term outcomes of ability attributions and how they may be negated are also discussed.

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Gender; teacher feedback; women in science

Women are underrepresented in Science, Technology, Engineering and Mathematics (STEM) careers in the USA (National Science Foundation, Division of Science Resources Statistics, 2015) and across Europe (European Round Table of Industrialists [ERT], 2009). This underrepresentation is often attributed to 'leaky pipeline' attrition from STEM subjects; where more girls drop out of STEM subjects at every stage in education leaving few working in these fields as adults (e.g. Weisgram & Bigler, 2007). The relatively smaller numbers of women in STEM careers may help to sustain a stereotype that science is a 'masculine' domain in which girls do not belong (Good, Rattan, & Dweck, 2012). The issue appears to be incrementally damaging, as more women leave the subject at each level, and persistent, as the problem remains regardless of various interventions (Cronin & Roger, 1999).

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Gender differences in subject choice and careers

There are clear gender differences in terms of subject choices at school and beyond in terms of career choices. For example, in 2012, only 14% of young women chose to study STEM subjects, while 39% of young men chose to do so, and men make up 84.5% of the STEM workforce (OECD, 2015). However, it is important to note that women are not underrepresented in all science subjects. In fact women are often overrepresented in life and health sciences both in terms of study and careers (EU, 2009; National Science Foundation [NSF], 2014; NSB, 2010). It is therefore important to examine why girls may be specifically leaving STEM subjects and careers.

Previous research has examined a range of reasons why girls may be opting out of STEM. Girls are not leaving STEM subjects because they perform poorly in them. Indeed in the Trends in International Mathematics and Science Study (TIMSS) survey of 2011, across all 42 participating countries, girls had a 12-point advantage in biology and a 10-point advantage in chemistry while boys and girls performed equally well in physics (Martin, Mullis, Foy, & Stanco, 2012). However, these talented girls are less likely to go on to study STEM subjects at advanced level, university and to make careers in them. The current paper suggests a novel approach to encourage girls to remain in STEM subjects by modifying teacher feedback in order to change girls' attributions around their potential success in STEM.

Attribution theory

Attribution theory suggests that we search for reasons for our successes and particularly our failures (Heider, 1958; Weiner, 1972). These attributions can impact our emotional reactions and future behaviours (Graham, 1991, 1994; Weiner, 1985, 1972; Weinder & Kukla, 1970). There are three key causal dimensions within attribution theory: locus, stability and controllability (Weiner, 1985, 1986). In terms of locus, we can attribute educational outcomes externally, for example, to having a good teacher or luck, or we can attribute them internally, for example, to our efforts and abilities. It has been found that attributing internally leads to more positive outcomes as we believe that we have control over our actions and thus the result (Rotter, 1954). However, it is clear that even when we attribute outcomes internally, the attribution may differ in terms of stability and controllability. Stability relates to whether the cause is seen as stable or varying over time. For example, ability levels would be seen as stable, as they are relatively fixed. In contrast, our effort levels can change depending on the task, situation and our motivation. Finally, controllability relates to whether the cause is seen as being within personal control or not. For example, ability is not usually seen as being within personal control; in contrast, effort is seen as controllable as we can choose how much to study for an exam.

Theory of intelligence

This literature has informed the work of Dweck and colleagues, who state that individuals view intelligence in either entity or incremental terms (e.g. Dweck, 1999). Those who hold an entity theory think of intelligence as a fixed trait which cannot be changed. In contrast, those who hold an incremental theory think of intelligence as malleable and easily changed with effort. Thus, those who hold an entity theory attribute outcomes to internal, stable and uncontrollable factors, that is, ability while those who hold an incremental theory attribute outcomes to internal, unstable and controllable factors, that is, effort. A wealth of research suggests that those who hold an incremental theory show more positive educational outcomes including higher grades and persisting in the face of failure (Dweck, 1999). This is because incremental theorists believe that they can change future outcomes by changing their actions. For example, attributing a bad test mark to not studying enough is likely to lead an individual to work harder for their next test and therefore succeed. In contrast, attributing a bad test mark to ability levels which cannot be changed is likely to lead an individual to feel demotivated and therefore unlikely to work hard in future. Theory of intelligence has also been linked to learning goals and the tasks which learners engage with (Hong, Chiu, Dweck, Lin, & Wan, 1999; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). For example, those who hold an incremental theory may be more likely to choose challenging tasks where they will develop their skills, in contrast, those who attribute more to ability and hold an entity theory often choose easier tasks where they will perform well and thus 'prove' their abilities. If theory of intelligence can impact task choice in class, it may also impact subject choice.

Furthermore, while people hold a general theory of intelligence, they may have different views of intelligence in different subjects. For example, there is some evidence that success in STEM subjects is more often seen as a result of abilities than effort (Howe, Davidson, & Sloboda, 1998). Indeed, over 80% of young people in one survey agreed that 'scientists are brainy' (ASPIRES, 2013). If it is believed that innate ability is required to succeed STEM, but a learner does not believe that they have this innate ability, then they will be unlikely to choose to study the subject. This is because ability is seen as stable and uncontrollable and therefore not within their control. Moreover, there is a common misconception that people are either talented at mathematics or language and that boys are stronger in maths, while girls are stronger in English (Steele, 1997). This is reflected in the fact that, in the UK, the most popular GCSE subject for girls is English and for boys is Maths (Department for Education and Skills, 2006). Thus girls' choices to study STEM subjects may suffer from a double bind of being both perceived to be a matter of innate ability and being an ability that is perceived to be possessed more 'naturally' by males.

Gender differences in origins of ability beliefs

As previously discussed, girls often outperform boys in STEM, so why then should it be the case that they are unlikely to persist in studying it at a higher level? It has been found that men's perceptions of their ability in science arise primarily from their performance in STEM tasks. In contrast, women did not assume that their performance reflected their underlying ability. Instead, they relied more on interactions with others to build a picture of their ability (Zeldin, Britner, & Pajares, 2008; Zeldin & Pajares, 2000). Therefore, high performing girls may not use their marks as the key indicator of their abilities and may instead look to teachers to give them an idea of their ability in STEM. This difference in the source of ability belief may go some way to explaining why girls are leaving STEM subjects. Additionally, the literature suggests that boys and girls receive different forms of feedback from their teachers, which may also help to explain why boys are more likely to take STEM subjects. For example, boys receive more feedback and interact more with teachers, specifically in maths lessons (Meece, Eccles, Kaczala, Goff & Futterman, 1982). Additionally, Eccles and Wigfield (2002) observed classrooms and found that girls received more negative academic feedback than boys in maths and science classes. If girls are using teacher feedback, more than boys are, to develop a picture of their abilities in STEM, this pattern of feedback may lead girls to feel that they are less likely to succeed in STEM.

Feedback

It is therefore important to explore whether it is possible to change girls' perceptions of their ability in STEM subjects. One way in which we can do this is via teacher feedback. Dweck (1999) suggests that feedback can be given in person or process forms. Person feedback relates to the traits which people possess, and focuses on their stable abilities, for example, 'You are really good at this.' If it is perceived that innate talent is needed to succeed in a subject then it may be that person feedback, which explicitly states that someone possesses this ability, may increase the likelihood of a person taking the subject. In contrast, process feedback relates to the way that a person went about the task and focuses on their controllable efforts, for example, 'You tried really hard at this.' If it is thought that innate talent is needed to succeed in a subject then perhaps this form of feedback may discourage young people from taking it. Process feedback may in fact implicitly suggest that students need to work hard because they are not talented in the subject.

There is evidence that teachers tend to praise boys using person terms while girls receive more process feedback (Burnett, 2002; Dweck, Davidson, Nelson, & Enna, 1978; Koestner, Zuckerman, & Koestner, 1989). This may mean that girls are less likely to think they have the ability to succeed in STEM and may go some way to explaining why girls are less likely to take STEM than boys. Thus, it may be hypothesised that giving person forms of feedback may encourage both genders to take STEM but that this may be particularly powerful for girls as they may use interpersonal interactions to develop their concept of their ability and may also be less likely to commonly receive person feedback.

A further benefit to using feedback to encourage girls into STEM is that it is a very 'light touch' intervention. If it was found to be successful in encouraging girls into STEM, it could then be used in many schools as it is neither time, nor resource intensive. Other interventions which have been used to encourage girls into STEM (e.g. Jayaratne, Thomas, & Trautmann, 2003; Lockwood, 2006; Marx & Roman, 2002; Stout, Dasgupta, Hunsinger, & McManus, 2011) have involved collaboration with parents and local industry and workshops of several days duration (McCullough, 2002). With an ever expanding curriculum to cover and a limited budget it is often difficult to expand these interventions to a large number of schools. Therefore, it is important to examine how we can encourage girls to persist in STEM during the routine course of the school day.

The current study

There are clear ethical and practical reasons for not being able to study the effects of feedback on longer term academic subject choices directly. The current research therefore used a tried and tested scenario methodology, where participants are asked to imagine themselves in a situation, to examine whether teacher feedback impacted young people's subject choice. The scenario methodology has been used previously to ethically and practically examine children's and young people's responses to a range of situations such as success and failure (Kamins & Dweck, 1999; Skipper & Douglas, 2012). This method also minimises the impact of extraneous variables such as current relationships with the teacher. Furthermore, it was decided that in the current research we would work with young people who were in the process of considering which subjects to study further. This meant that the scenarios would reflect the young peoples' current experiences making them relevant and important, thus further supporting the use of this method.

This study explored the impact that person, process and no feedback (control condition) had on girls' and boys' intentions to take engineering and whether they thought that natural ability or effort would lead to success in engineering, a STEM subject. Engineering was chosen because 91% of the engineering workforce in the UK is male (The Institute of Engineering and Technology, 2015). Furthermore, this was a subject which no schools offered but one which is available to study at GCSE level. It was important that participants had no prior knowledge of engineering, as this could have impacted their perception of their skill in it.

To begin, participants were asked how much both ability and effort contributed to success in science and non-science subjects. This allowed us to explore whether ability would be seen as more important in science subjects. Participants then read a scenario where they met a new teacher who gave them information about engineering and either person, process or no feedback suggesting that they continue with the subject. It was important for the current study to include a control condition where participants were told they could take the subject, but did not receive any other feedback, in order to infer the impact of different types of feedback compared to a neutral baseline (Skipper & Douglas, 2012). Participants were asked how likely they would be to take engineering. They were then asked how much effort and ability would contribute to their performance in the subject.

It was hypothesised that:

H1, ability levels would be seen as contributing more to success in science subjects than non-science subjects.

H2, boys would be more likely to take engineering than girls.

H3, young people would be more likely to indicate that they would take engineering in the person feedback rather than process feedback or no feedback condition; because it suggests that they have the underlying ability to succeed in the subject.

H4, the effect of person feedback would be stronger for girls than boys as they less commonly receive this form of feedback and may use interpersonal interactions more to form conceptions of their abilities.

H5, those who received person feedback would see success in engineering as being more due to ability levels, than those who received process or no feedback.

Method

Participants

Participants ($N = 486$) were recruited from four schools in middle income areas of the South East of England. All were aged 13 and were in the process of deciding which subjects to study for national level (GCSE) exams. The sample consisted of 306 boys and 180 girls, the gender split was uneven as a large boys' school agreed to participate while the girls' school was smaller.

Materials and procedure

Consent was obtained from head teachers, parents and participants before the study was conducted. To begin participants were asked to fill in a series of equations to illustrate how much they believed that ability and effort contributed to success in different subjects. Participants were asked, 'Do you think success in *physics* is due to ability or effort levels?' Three subjects were science based (physics, chemistry and maths) and three were not sciences (English, French and history). This question was answered by writing a number indicating the percentage that both effort and ability contributed to success; therefore, higher numbers indicated a greater proportion of influence on success, with 50 indicating that both were equally important. This was adapted from Mueller and Dweck (1998).

Participants were then asked to imagine themselves vividly in the scenario they were about to read and to answer the questions imagining this had really happened to them. To begin, participants read a paragraph reminding them that they would soon have to decide which subjects they would like to study further. They were asked to imagine that their year group would be the first to be offered a new subject which would be taught by a new teacher. Students were told that they would have individual meetings with the new teacher, who would advise them whether they should take this new subject. This recommendation would be based on students' current grades and informal discussions the new teacher had with existing teachers. This information was included to make the scenario as real as possible to participants.

Participants were then asked to imagine they were attending a meeting with the new teacher. This meeting began with the teacher giving them a brief description of what engineering is. This was based on the description of the engineering given by national examination boards and read as follows:

> Engineering is the application of ingenuity, scientific knowledge, natural laws and physical resources, to overcome problems. Engineers are concerned with developing economical and safe solutions to practical problems by applying mathematics and scientific knowledge while considering technical constraints. This course will help you develop a design specification and design proposals for an engineered product and devise and apply a range of tests to draw up a final design solution.

Participants were then given either person, 'You could take this course because you are really clever,' process, 'You could take this course because you are working really hard,' or no feedback, 'You could take this course.'

Participants then responded to the dependent variables and were asked, 'How likely would you be to take *engineering*?' This question was answered on a 5-point scale. Participants were also asked, 'Do you think success in engineering is due to ability or effort levels?' This question was again answered by writing a number indicating the percentage that both effort and ability contributed to success; therefore, higher numbers indicated a greater proportion of influence on success, with 50 indicating that both are equally important. This was adapted from Mueller and Dweck (1998).

Therefore, we used a 2 (gender) × 3 (feedback) design. Participants completed the questionnaires individually during class time and were fully debriefed when they had completed the questionnaire.

Results

In order to test H1, that ability would be considered to be a more important predictor of success in science than non-science subjects, a repeated measures *t* test was conducted. As the data were shown in percentages, they were transformed using an arcsine transformation. An average of the ability percentages given for each of the three sciences and each of the three non-sciences was calculated to give one value as differences within the subjects were not significant. Results indicated that success in sciences was seen as more due to ability than success in non-science subjects $t(482) = 6.55$, $p < .000$, (science $M = 57.47$, SD = 15.66; non science, $M = 52.64$, SD = 15.34). This provides support for H1.

A univariate ANOVA including both gender (male and female) and type of feedback (person, process and control) as IVs and likelihood of taking engineering as the DV, was used to explore H2, H3 and H4. Descriptive and inferential statistics from this analysis can be found in Table 1. In line with H2, boys were more likely to take engineering than girls. H3 predicted that students would be more likely to take engineering if they received person feedback compared to the process and control conditions. Results provided support for this hypothesis as feedback was shown to impact likelihood of taking engineering (see Table 2). Bonferroni correction revealed that participants in the person condition were more likely to take engineering than those in both the process ($p < .001$) and control conditions ($p < .001$). Differences between the process and control group were not significant ($p = 1.00$). We then explored the interaction between our two IVs and found no gender differences in the impact of feedback in engineering, $F(2,472) = .701$, $p = .469$ (see Table 1). Thus boys and girls responded in a similar way to feedback. This does not support H4.

We also tested whether feedback would impact how much students saw success in engineering as being due to their ability levels (H5). Again we performed an arcsine transformation on our percentage data. A one way ANOVA revealed that feedback did impact

Table 1. Mean (and standard deviation) ratings for boys' and girls' intentions to take engineering overall and in each of the three conditions.

	Boys		Girls		ANOVA
Take engineering overall	3.23	(1.23)	2.67	(1.07)	$F(1, 472) = 20.86$, $p < .01$, $\eta^2 = .043$
Take engineering person	3.70	(1.06)	3.09	(1.01)	
Take engineering process	3.03	(1.31)	2.47	(1.12)	
Take engineering control	2.92	(1.89)	2.60	(.99)	

Table 2. Mean (and standard deviation) ratings for intentions to take engineering and percentage success attributable to ability (as opposed to effort).

	Person		Process		None		ANOVA
Take engineering	3.51	(1.08)	2.78	(1.26)	2.80	(1.13)	$F(2,472) = 14.25$, $p < .000$, $\eta^2 = .057$
Success due to ability	57.67	(18.36)	51.78	(19.40)	52.88	(19.26)	$F(2,457) = 3.82$, $p = .022$, $\eta^2 = .017$

students' perceptions of how much success was due to ability (see Table 2). Bonferroni correction revealed that the difference between the person and process conditions was significant ($p = .024$). However, differences between the person and control conditions were not significant ($p = .139$) and differences between process and control conditions were not significant ($p = 1.00$).

Discussion

Results from the current study generally supported the hypotheses. Young people were more likely to see success in science subjects as being due to ability than success in non-science subjects. This supported H1. There was also a clear gender bias in subject choice; boys were more likely to take engineering than girls, thus supporting H2. Furthermore, results supported H3 which suggested that specifically person feedback (which suggested that they had the ability to succeed) would increase the likelihood of young people indicating that they would take engineering. However, H4 which predicted that the effect of person feedback would be stronger for girls than boys was not supported as young people responded in a similar way to feedback regardless of gender. Furthermore, those who received person feedback saw success in engineering as being more due to ability levels, than those who received process feedback, supporting H5. However, there was no difference between those who received person and no feedback and those who received process and no feedback.

Gender differences in subject choice

The finding that boys were more likely to take engineering than girls reflects gender differences in subject choice which are found internationally (OECD, 2015). Thus, although great efforts are being made to encourage girls into STEM we are still seeing traditional patterns of subject choice. This is particularly interesting in the current study as the participants had not previously studied engineering and were only provided with a brief description of what it entailed. However, they presumably used their knowledge of STEM to decide whether engineering would be 'for them'.

The lower numbers of women in STEM is important, not just in terms of equality but also to meet economic need for shortfall in supply of STEM skilled workers (CaSE, 2014). For example, in the UK there is a need to double the number of graduates and apprentices in engineering alone by 2020, and other countries face a similar shortfall. This increase will not be possible without increasing the number of women pursuing STEM subjects and careers (CaSE, 2014).

Effects of feedback on intentions to take engineering

In this study, young people perceived that success in science subjects was more due to ability than success in non-science subjects. This is in line with other research (Howe et al., 1998) and suggests that STEM subjects may be viewed differently to other subjects, with ability levels viewed as contributing more to success, compared to other subjects. This means that person feedback, which suggests that young people have the ability they feel they need to succeed in STEM, will encourage them to take it. Indeed, the current research indicates that person feedback encouraged young people to choose engineering. This may be because it encouraged them to feel that they had the ability that they felt they needed to succeed in engineering (ASPIRES, 2013). An implication from the current study is that teachers should use more person forms of feedback to encourage students to persist in engineering and perhaps also other STEM subjects. A benefit of this approach is that it can be easily used in the classroom as part of the routine course of the lesson or in guidance counsellor meetings and does not require time and resource intensive interventions which may be challenging to deliver on the national scale required to fully increase diversity in STEM.

However, the literature does not necessarily suggest this approach would lead to positive outcomes in the longer term. Previous research (Kamins & Dweck, 1999; Mueller & Dweck, 1998; Skipper & Douglas, 2012) suggests that following success, there is little difference between those who received person and process feedback; all feel equally positive. However, when students are faced with failure, those who received person feedback and therefore believed that they succeeded because of their ability levels were more likely to infer that failure was also caused by a lack of ability. Ability levels are seen as a fixed trait which cannot be changed (Weiner, 1972) so individuals feel unable to improve their performance. They therefore show lower levels of perceived performance, affect and persistence, a combination which Dweck termed a 'helpless response' (1999). In contrast, young people who received process praise and therefore attributed success to effort levels also inferred that their failure was caused by lack of effort. Effort levels can easily be changed in the future (Weiner, 1972). Therefore, these individuals show a 'mastery response' with high levels of perceived performance, positive affect and persistence.

Furthermore, different forms of feedback have been associated with different learning goals (Hong et al., 1999; Mangels et al., 2006; Nussbaum & Dweck, 2008; Rhodewalt, 1994). Those who receive person feedback and believe that intelligence is stable often become focussed on showing that they possess this trait of intelligence. They are therefore likely to choose 'performance goals' which allow them to prove their ability. In contrast, those who receive process feedback and believe intelligence is malleable are more likely to choose 'learning goals' where they can develop their skills and learn new things (Dweck & Leggett, 1988; Elliott & Dweck, 1988).

Results from this study suggest that young people who received person feedback were more likely to take engineering. However, they were also more likely to view success in engineering as being due to their ability levels. It appears that person feedback increased their perception that innate ability was needed to succeed in engineering when compared to process feedback. In the longer term, if they chose to take engineering, then this perception could lead them to choose performance goals in order to validate their intelligence. They may also be less likely to take risks, such as choosing challenging tasks, and instead choose easy tasks where they know they will do well (Elliott & Dweck, 1988). This, in turn, could limit their learning opportunities.

Furthermore, attributing success to ability may lead young people to respond negatively to future failure. As previously discussed, those who hold an entity theory of intelligence respond more negatively to failure as they infer that failure signals that they lack the ability they need to succeed in the subject. As ability levels cannot be changed they may infer that they do not possess the ability to succeed in the subject and this may lead them to be more likely to drop it. Thus, suggesting that teachers use person feedback to encourage young people to feel that they possess the intelligence needed to take engineering could be counterproductive if it decreases the likelihood of young people choosing tasks where they could learn and also makes them more likely to drop the subject in future.

It is important to note that in the current study there was no difference between young people who received person feedback and no feedback in terms of their attributions for success. This means that person feedback did not lead students to be more likely to attribute success in engineering to ability than they would naturally and without any feedback. Thus it is important to understand how best to maximise the positive impacts of person feedback and minimise the negative. One way to do this could be to use person feedback to encourage students to take science subjects but follow this up with process feedback. When students embark on a higher level of study this gives them the opportunity to reflect on how they can be successful in the new course. This means that this could be a key time when teachers could emphasise an incremental view of intelligence and encourage students to view success as being down to their efforts. Although it has been suggested that students' views and attitudes develop gradually and over time, there are also transition points in education when they can be influenced (Osborne, Simon, & Tytler, 2009). Therefore teachers could use process forms of feedback to try to change students' theory of intelligence to a more incremental one when they embark upon STEM subjects. Previous research has found that delivering process feedback can be successful in impacting theory of intelligence in short-term experiments (Kamins & Dweck, 1999; Mueller & Dweck, 1998). Indeed, in the present study, those who received process feedback were less likely to attribute potential success to ability levels than those who received person feedback. Therefore process feedback delivered about STEM across the longer term, may help to minimise an entity view of success in STEM.

Teachers could also explicitly state what STEM assessments are testing. For example, Aronson (1999) (cited in Aronson, Fried, & Good, 2002) gave students a test of 'verbal ability' which was either described as malleable, fixed or they were given no further information. Results showed that those in the 'fixed' ability condition were most anxious and scored lower than those in the control condition, while those in the 'malleable' condition showed the lowest anxiety and scored the highest. Thus, it may be that if teachers explicitly state that STEM ability is malleable then young people may see success as more due to effort than ability. Finally, Blackwell, Trzesniewski, and Dweck (2007) found that it was possible to encourage students to hold a more incremental view of maths with a targeted intervention. Teachers could also use light touch interventions, for example, illustrating how the brain grows as we learn new things, to promote a more incremental view of success in STEM. Therefore, using process feedback, explicitly explaining that success in STEM is controllable and light touch interventions to change theory of intelligence could all be used to encourage students to view success in STEM as being more about their efforts. This could potentially negate the potential negative impact of person feedback.

Gender differences in response to feedback

The current research found that boys and girls responded in similar ways to feedback. It had been hypothesised that girls would respond more strongly to person feedback encouraging them to take engineering. This is because previous research suggests that girls receive more negative feedback in science (Eccles & Wigfield, 2002) and are less likely to receive person feedback (Burnett, 2002; Dweck et al., 1978; Koestner et al., 1989). Furthermore, women's sense of self-efficacy in STEM has been found to be linked more to their interactions with others than from their actual performance levels (Zeldin & Pajares, 2000). However, current findings suggested that both boys and girls responded similarly as person feedback encouraged them to be equally likely to take engineering. Therefore, the observation that teachers give more positive feedback, and crucially more person feedback, to boys in STEM may help to explain why they are more likely to choose these subjects.

However, differences in the delivery of feedback to boys and girls are not necessarily a conscious decision on the part of teachers, and may be a result of implicit bias (Hill, Corbett, & Rose, 2010). A meta-analysis from Kelly (1988) found that teachers were unaware of any differential responding to boys and girls in the classroom. Furthermore, even if teachers consciously attempted to give similar amounts of feedback to boys and girls, they may not consider the types of feedback they give. Even if they consider the ability versus effort connotations of their feedback, sentences such as 'You are a good drawer,' and 'You did a good job drawing' are so similar that teachers are likely to use them interchangeably (Cimpian, Arce, Markman, & Dweck, 2007). Therefore, differences in feedback delivery to boys and girls are unlikely to be due to conscious choice on the part of teachers. Thus, making teachers more consciously aware of the impact of their feedback may help them to consider the types of feedback they deliver to boys and girls and, crucially, the implicit effort/ability and therefore controllable/uncontrollable, stable/unstable connotations of this feedback.

It is also important to consider the fact that gender differences in subject choice are not wholly due to differential teacher communication, but are related to widely held cultural beliefs that young people are exposed to in a variety of settings. Eccles and Blumenfeld (1985) suggested this in their research, showing that teachers played a passive role in gender differences, consolidating rather than creating them. Therefore, teacher delivery of person feedback to encourage young people to take STEM subjects may lead to negative outcomes, such as a helpless response to failure. However, young people may already perceive that ability is required to succeed in STEM due to societal influences. Indeed, this appeared to be the case as there were no differences between young people who received person feedback or no feedback in their views ofhow much success in engineering was due to ability levels. Therefore, person feedback may not in fact lead to more negative outcomes than this initial perception.

Parental feedback may also have a strong impact on young people. For example, parental use of person feedback has been found to be strongly linked to children holding an entity theory of intelligence (Gunderson et al., 2013). This effect of parental feedback promoting an entity view of intelligence in general may also be found in STEM subjects. Society in general, including the media, also contribute to the stereotype of scientists as 'brainy' and having a 'gift' (ASPIRES, 2013), again promoting the view of science being a subject or career where an innate ability is required for success. Thus, consideration also needs to be given to the wider societal context, suggesting a need for interventions around changing perceptions of STEM at a broader societal level in order to lead to long term systemic change and encourage more women into STEM subjects.

Limitations

The present research indicates important perspectives for encouraging female participation in STEM studies and careers. A clear limitation is that the present methodology employed scenario-based measures to elicit participants' responses. Previous research on educational achievement has often used scenario methodology to allow researchers to examine children and young people's responses to various situations which are difficult or ethically questionable to create, for example, experiences of failure or criticism (e.g. Kamins & Dweck, 1999; Skipper & Douglas, 2012). Scenarios are a desirable means of collecting data in educational research because they allow for control of potential confounding variables such as young people's relationship with their teacher. The present results suggest that even though young people were not directly experiencing feedback, it did have an impact on their decisions. Additionally, because students were in the process of having discussions about subject choices with teachers the scenarios would have been relevant and important to them. However, it would be interesting to examine this in a more applied context. For example, future research could record real-world interactions between students and guidance counsellors and examine how the language and attributions used naturally by the counsellor impacts student subject choice in a more ecologically valid setting.

Furthermore, future research could measure variables such as; students' academic interests, self-concepts, perceptions of STEM and future aspirations before delivering a feedback intervention such as this. These variables are likely to give us a more nuanced understanding of the impact of feedback. Future research should also include greater exploration of, for example socio economic status and ethnicity. Previous research suggests that young people eligible for free school meals perform worse in GCSEs than students who are not eligible. Furthermore, students from certain ethnic groups such as Black Caribbean perform poorly compared to their White classmates (Department for Education and Skills, 2006). This pattern of underperformance is also found in STEM subjects and may mean that these young people cannot pursue STEM subjects at a higher level. Therefore, it is important to understand the intersections between gender and other variables to truly encourage diversity in STEM.

The present results suggest an intriguing, novel method of encouraging girls to take engineering and perhaps other STEM subjects. By giving them person forms of feedback, suggesting that they have the necessary ability to succeed in the subject, the current study suggests that we can encourage young people to take engineering. This suggests that participation in STEM can be encouraged as a part of usual classroom activities rather than other time and resource intensive interventions. This research also highlights the importance of teachers and other adults being aware of the different types of feedback they can give to boys and girls and the implicit messages contained in their feedback. Further research is needed to examine how to negate possible negative effects in the longer term (e.g. by combining this with process feedback or an intervention early in the academic year). In addition, different forms of feedback are reflective of innate biases in society and in order to create a fully diverse STEM workforce, it is also important to combat the wider systemic issues that can prevent women from pursuing education and careers in science.

Disclosure statement

No potential conflict of interest was reported by the authors.

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