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Perceived Connection to Instructor and Instructor Passion as Predictors of Transformative Experiences in Science

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Abstract: Transformative experience represents a deep-engagement construct and refers to experiences in which students use science content to see and experience the world in meaningful new ways outside the classroom. Such experiences are associated with deep learning (e.g., transfer) and engagement (e.g., academic and career choice) outcomes. However, research on individual factors predictive of transformative experience is limited. The current study investigated university geoscience students' perceptions of a connection to their instructor(s) and perceptions of their instructors' passion for the content as predictors of transformative experience. Controlling for students' initial interest and self-efficacy in the domain, we found both these factors to be predictive of transformative experience. These results suggest science teachers may be able to support engagement in transformative experiences by connecting with students and expressing a passion for the content.

Keywords: transformative experience; engagement; science education; interest; student–teacher relationship; teacher passion

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1. Introduction

Over the last few decades, increasing attention has been directed toward conceptualizing, measuring, and understanding science engagement [1–4]. One unique approach to studying science engagement is the research on *transformative experience* [5], as this research uniquely targets engagement extending beyond the classroom. Transformative experience refers to experiences in which students use curricular concepts in everyday, out-of-school life to see and experience the world in meaningful, new ways [6]. Like other science engagement constructs, transformative experience has been related to important learning outcomes, including enduring learning [7,8], deep understanding [9], conceptual change [8,10], transfer [11–13], identification with science [7], and academic and career choice [14,15]. In line with Dewey's [16] educational philosophy, transformative experience has also been advocated as a goal in its own right. The purpose of science education, from this perspective, is to transform and enrich individuals' relationship with the world by changing the way they see and experience it in everyday life outside of school [5].

In order to achieve this purpose, it is beneficial to identify individual factors associated with the occurrence of transformative experiences. Although some work has been done in this area [17], we still lack a solid research base linking individual factors to transformative experiences. Accordingly, the purpose of the current research was to investigate two individual factors as potential predictors of transformative experience: students' perception of a connection to their instructor(s) and students' perception of their instructors' passion

for the content. We conducted this investigation in the context of geoscience education in university settings.

1.1. Transformative Experience Theory

John Dewey was a prominent American educator and philosopher whose work has had an important influence on the development of contemporary motivation theories [18–20]. Work on transformative experience represents a neo-Deweyan motivational framework [21], drawing strongly on Dewey's theory of aesthetic and educative experience. Below, we briefly review how Dewey's work provides a basis for transformative experience theory.

Central to Dewey's [22] aesthetics is the construct of "an" experience. In contrast to ordinary experience, "an" experience is characterized by unity, consummation, and transformation. The arts provide us with experiences that expand our horizons by changing the way we perceive the world "thus leaving us and the world itself irrevocably changed" [23] (p. 33). For example, Van Gogh's *Wheatfield with Crows* may impress upon a viewer a paradoxical sense of nature as tumultuous loneliness and nature as restorative health. This experience may awaken anticipation in the viewer leading to viewing and experiencing nature through this lens.

Pugh and colleagues [5,6,24,25] have argued that such aesthetic experience is implicit in Dewey's [16,26,27] writings on educative experience, particularly his construct of *ideas* (i.e., conditional meanings or possibilities). Like "an" experience, ideas are consummatory experiences that expand perception [6,25,28,29]. That is, curricular concepts can become *ideas*; possible ways of seeing and making sense of the world. Such ideas can awaken anticipation leading students to see and experience the world in new ways. This type of experience with curricular content has been labeled "transformative experience" [8].

1.1.1. Defining a Transformative Experience

Based on Dewey's characterization of "an" experience and ideas, Pugh [6] defined three characteristics of transformative experience: motivated use, expansion of perception, and experiential value. *Motivated use* refers to the application of school content in contexts (particularly out-of-school contexts) where application is not required. If learning is going to enrich and expand everyday experience as Dewey hoped, then it can't remain confined to the classroom. *Expansion of perception* refers to seeing (or re-seeing) aspects of the world (e.g., events, objects, issues) through the lens of the science content. *Experiential value* refers to the meaning and value associated with an expansion of perception. Just as art can bring more value to everyday experience, so science ideas can help us find additional value in everyday objects, events, or issues.

An example of these characteristics is found in a study by Pugh et al. [30]. In this study, a high school biology teacher collaborated with the researchers to teach for transformative experiences. Among other things, students were asked to take pictures when they noticed connections to curricular content and post the picture with an explanation to a class site. One student (Madison) posted a picture of her TV displaying a commercial with Bigfoot in it. In her caption, she explained, "I had never thought of it before, but since I literally see science everywhere now, I realized that Bigfoot would probably be related to us in some way. I was thinking, if Bigfoot is real, how closely related would he be to us, and what is our common ancestor?" (p. 346). She listed other questions and later added: "Edit: I literally just found a picture of a primate family tree with the Sasquatch!" (p. 346). Asked about this edit in an interview, Madison commented, "I actually did some research on it and, like, found the image that linked it to orangutans and stuff and I just thought that was really funny" (p. 348). These actions and comments illustrate both motivated use and expansion of perception. Even though Madison was given an assignment to make connections and post pictures, she in her own words, came to "literally see science everywhere now". Further, she chose to research the topic on her own. She engaged in motivated use by making the science content a regular part of her everyday life. In doing so, she also experienced an expansion of perception. That is, she came to see things in the world (e.g., Bigfoot) in a

new way by perceiving them through the lens of evolution. Moreover, she valued the way in which the science content enriched her everyday experience. In an interview, she commented, "[it] was actually really fun and it helped me see or take the classroom into my personal life" (p. 348). Such valuing is representative of experiential value.

1.1.2. Connections to Other Constructs

Transformative experience fits within the broader context of research on engagement. Engagement refers to the quality and intensity of student involvement and is a holistic concept encompassing behavioral, cognitive, and affective dimensions of learning [31,32]. Transformative experience is likewise a holistic concept with the characteristics of motivated use, expansion of perception, and experiential value roughly corresponding to the behavioral, cognitive, and affective dimensions [6]. Unique within the engagement literature, these characteristics place particular emphasis on *engagement extending beyond the classroom*.

Transformative experience also has much in common with the construct of interest. Interest is typically conceptualized as sustained attention to or engagement with a content area and results from an interaction between the individual and environment [33,34]. Transformative experience can be considered both a trigger for the development of interest and a manifestation of interest [35]. That is, as students engage with content in everyday experience and use it to perceive the world in meaningful new ways, they are likely to develop greater interest in that content domain, as has been found in prior research [10]. In addition, students with an interest in a content domain are likely to engage with such content in the form of a transformative experience. Indeed, interest has been found to be a strong predictor of transformative experience in prior research [14,17]. Recently, Heddy et al. [36] confirmed a reciprocal relationship between interest and transformative experience.

1.2. Factors Related to Transformative Experience

To pursue transformative experience as an educational goal, it is important to identify individual factors associated with undergoing transformative experience. As stated in the prior section, interest has been found to be an important predictor of transformative experience [14,36], with maintained situational interest being a stronger predictor than triggered situational interest [17]. In addition, prior research has identified science identity, mastery goal orientation, positive emotions and task values, and openness to experience as factors predictive of transformative experience [12,17,36–39]. In the current study, we were interested in exploring two additional factors as possible predictors of transformative experience: perceived connection to instructor and perceived instructor passion for the content.

1.2.1. Perceived Connection to Instructor

Researchers have primarily investigated the student–teacher relationship at the primary and secondary levels of education and found that positive relationships are related to engagement outcomes such as positive attitudes, behaviors, and emotions [40,41]. Significantly less research has investigated the student–instructor relationship at the university level [42,43], which is the context of the current study. Nevertheless, the existing research aligns with that conducted in primary and secondary contexts. Positive relationships with instructors have been found to predict intrinsic motivation [44], self-efficacy [45], effort [46], and motivation and engagement generally [47]. Further, the research suggests faculty–student relationships influence students' academic and career choices [48,49].

Given these connections between positive student–instructor relationships and positive engagement outcomes, we hypothesized positive student–instructor relationships would also predict transformative experiences. We selected perceived connection to instructor as our student–instructor relationship variable because we were particularly interested in students' perceptions of the nature of this relationship. We conceptualized this

variable as students' perception of a sense of connection, relatedness, and similarity to their instructor(s).

In prior research, we [14] found domain interest to be a significant predictor of geoscience students' academic and career choice with significant indirect paths through connection to instructor and/or transformative experience depending on participant gender and the specific outcome targeted. Within this model, we found the path between connection to instructor and transformative experience to be significant for both male and female participants.

In the current study, we followed up on this research using an overlapping data set and investigated the predictive relationship between students' perceived connection to their instructor(s) and their reports of undergoing transformative experiences while controlling for their initial interest in the content domain (geoscience) as well as their existing self-efficacy in the domain. Unique to the current research, we examined this relationship in connection with students' perceptions of their instructors' passion for the content.

1.2.2. Instructor Passion

Prior research confirms instructors' expression of enthusiasm and passion for the content can have positive effects on engagement outcomes such as interest and intrinsic motivation [50,51]. Hatfield et al. [52] coined the term *emotional contagion* in reference to a process of one's emotions influencing the emotions of others. Researchers have confirmed that instructors' emotions are indeed contagious [53,54]. Thus, it seems likely that instructors' expression of passion for the content would influence students' passion for the content and facilitate students' transformative experiences with the content. For the purposes of the current research, we conceptualized instructor passion as students' perception of their instructors' passion, excitement, and love for the content.

This supposition has only been investigated indirectly through intervention studies focused on fostering transformative experiences. In these studies, instructor enthusiasm and modeling of transformative experience have been included as components of interventions effective at fostering transformative experiences [8–10,13,24,30]. Enthusiasm included expressing excitement and interest in the content and is equivalent to how we conceptualized expressing passion for the content in this paper. Modeling included sharing experiences of applying content in everyday life and finding meaning in doing so. For example, a university biology teacher expressed his passion by referencing a show on polar bears he recently watched and explaining that it was so cool to be able to view these animals through the lens of adaptation and natural selection [10]. Thus, the existing research supports a connection between instructor expression of passion for the content and transformative experiences. However, instructor passion has not been investigated apart from other components of the intervention models. Consequently, its unique relation to transformative experience has not been directly investigated. Further, instructor passion has not been included as a factor in models predicting transformative experience. The current research included instructor passion as a predictor of transformative experience along with perceived connection to their instructor.

In addition, we hypothesized an interaction between connection to instructor and instructor passion. Prior research confirms that models tend to be more influential when they are relatable [55,56]. Thus, students who perceive a greater connection to their instructor(s) are likely to be more influenced by instructor expression of passion for the content.

1.2.3. Control Variables

We chose the constructs of domain interest and self-efficacy as control variables. As explained previously, transformative experience intersects with the construct of interest and interest has been found to be an important predictor of transformative experience [14,17,36]. Moreover, perceived connection to instructor and instructor passion are potentially influenced by students' existing interest in the domain. Thus, we wanted to control for initial

interest to see if connection to instructor and instructor passion were predictive of transformative experience even accounting for initial interest.

Interest has been conceptualized in multiple ways [34]. We focused on students' existing domain interest and, in line with many conceptions of interest, we conceptualized interest as including both feeling and value components. Feeling refers to a sense of liking or enjoying and value refers to perceptions of usefulness and practicality [33,57]. In addition, we included an identity component focused on students' sense of connection to and identification with the content domain [58]. Thus, we were interested in students' existing perceptions of how much they enjoyed the content domain, found it useful, and identified with it.

Self-efficacy refers to a belief in one's ability to be successful at a task [59]. Self-efficacy is a core motivation construct related to engagement outcomes such as academic and career choice [60,61]. Consequently, we chose to include it along with interest as a control variable in our analysis.

1.3. Current Study

The purpose of the current study was to investigate the potential degree to which geoscience students' sense of connection to their instructor(s) and perception of their instructors' passion for the content are predictive of engagement in transformative experience, controlling for students' initial levels of interest and self-efficacy in the domain. In addition, we were interested in investigating the potential interaction between perceived connection to instructor and instructor passion in predicting transformative experience.

We hypothesized perceived connection to instructor, perceived instructor passion, and the interaction between these would be predictive of transformative experience, even controlling for initial domain interest and self-efficacy.

2. Materials and Methods

2.1. Participants

Data were collected from students enrolled in undergraduate geoscience courses at six universities in the United States. Each university had a geoscience department with a primary undergraduate degree focused on geology and granted at least 100 undergraduate geoscience degrees over a 10-year period. Participants were recruited from courses restricted to geoscience majors and courses open to non-majors from across the university. Participants were recruited via departmental listservs, posters, classroom announcements, and emails from instructors.

A total of 343 individuals completed a pre-survey and post-survey. In terms of demographics, 66.2% of participants self-reported their gender as female and 33.8% as male. Further, 73.8% self-reported their race/ethnicity as White, non-Hispanic, 10.5% as White, Hispanic, 4.4% as Asian, 2.9% as Black, 6.7% as mixed race, and 1.5% as other races or did not report their race/ethnicity. Participants included geoscience majors (35.6%) and non-majors (64.4%). The mean age of participants was 22.1 years old.

2.2. Procedure

A pre-survey including measures of domain (geoscience) interest and self-efficacy was administered two weeks after the start of the semester. A post-survey including measures of perceived connection to instructor(s), perceived instructor passion, and transformative experience was administered three weeks from the end of the semester.

2.3. Measures

The domain interest measure contained five feeling-oriented items (e.g., I enjoy the geosciences), four value-oriented items (e.g., geoscience concepts are practical for me to know) adapted from Harackiewicz et al. [62], and four identity items (e.g., I feel a connection to the geosciences) adapted from Pugh et al. [12]. The three components of interest did not separate in exploratory factor analysis. Extraction based on Eigenvalues

greater than 1 yielded a single factor with all item loadings greater than 0.721. The 13-item scale had strong reliability ($\alpha = 0.97$).

Self-efficacy was measured with five items (e.g., Even if the work in my geoscience course[s] is hard, I can learn it) adapted from the Patterns of Adaptive Learning Scales (PALS) [63]. One item moderately crossloaded with the interest scale in exploratory factor analysis (0.414 on the interest factor and 0.674 on the self-efficacy factor). This item was dropped. The remaining items loaded on the self-efficacy factor at 0.777 or greater with crossloadings less than 0.264. The interest items all had crossloadings of less than 0.338 on the self-efficacy factor and greater than 0.724 on the interest factor. Confirmatory factor analysis supported these results. A two-factor model with interest as one factor and the four-item self-efficacy scale as the second factor yielded good fit statistics: Satorra–Bentler scaled chi-squared = 806.369 ($p < 0.000$), non-normed fit index (NNFI) = 0.972, comparative fit index (CFI) = 0.975, and the standardized root mean square residual (SRMR) = 0.0635. The four-item self-efficacy scale had good reliability ($\alpha = 0.86$).

Connection to instructor(s) was assessed with a three-item scale (e.g., I felt I connected to the instructor[s] in my geoscience course[s]) ($\alpha = 0.91$) developed by the researchers. Perceived instructor passion was assessed with a three-item scale (e.g., Compared to other university instructors, my geoscience instructor[s] this semester was/were very passionate about the content) adapted from Frenzel et al. [50] ($\alpha = 0.88$). These two constructs separated cleanly in exploratory factor analysis; all items loaded on their respective factor at greater than 0.828 and crossloadings were less than 0.298. All the above scales used a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree).

Transformative experience was assessed with a 25-item measure adapted from Pugh et al. [12] and, in line with original instrument validation, we utilized a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). The measure contained items targeting the three qualities of a transformative experience: motivated use (e.g., I look for chances to apply my knowledge of geoscience in my everyday life), expansion of perception (e.g., The concepts I learned in my geoscience classes changed the way I see the Earth), and experiential value (e.g., Geoscience concepts make the Earth much more interesting). In addition, the survey items were based on the Pugh et al. [12] premise that transformative experience exists as a continuum ranging from in-school to active out-of-school engagement, with out-of-school engagement representing a deeper level of engagement. For example, some students may apply content, perceive the world in terms of this content, and find interest in the content while in class but not in their everyday, out-of-school lives. These students represent a lower end of the continuum. Other students may apply content and perceive the world in terms of this content, not just in class, but also in their everyday, out-of-school lives and they may find deep value in doing so. These students represent the upper end of the continuum and more fully epitomize genuine transformative experience. Consequently, the survey contained items targeting both in-class and out-of-school items. For example, the item "In class, I find it interesting to learn about geoscience concepts" targeted in-class value, whereas the item "I find that geoscience concepts make my current, out-of-school experience more meaningful and interesting" targeted out-of-school value (i.e., genuine *experiential* value).

Per precedent [12], Rasch analysis [64] was used to develop a composite score for the transformative experience measure using WINSTEPS software [65]. Rasch is a valuable tool for measuring complex constructs like transformative experience because it provides information on whether the different characteristics hold together and function as a unidimensional construct [66]. In addition, the Rasch model provides rich information about participant performance and the nature of the construct being measured [66]. Instead of treating all items equally and computing an overall score (e.g., a mean of 3.1 on a 4-point scale), the Rasch model places items in a hierarchy of easiest to most difficult to endorse and provides information about which items participants were likely and unlikely to endorse.

Following Wright and Linacre [67], we used infit MNSQ > 1.4 as a cutoff for misfitting items (i.e., items not holding together with the others in the Rasch model). No items were found to be misfitting. For the measure, both person and item reliabilities were strong (0.95 and 0.99, respectively), indicating a strong probability of finding a similar ordering of persons and items for similar samples (i.e., the ordering of participants in terms of level of transformative engagement and items in terms of difficulty to endorse are likely to remain stable). In addition, the person separation statistic (4.67) indicated the measure sufficiently distinguished participants into different levels of engagement along the transformative experience continuum. Specifically, according to guidelines provided by Wright and Masters [68], a separation of 4.67 suggests participants could be separated into six to seven groups representing different levels of transformative engagement. The item separation statistic (12.78) was high suggesting the items could be distinguished into many levels of endorsement difficulty.

3. Results

Table 1 displays descriptive statistics and correlations. On average, students indicated they agreed to the self-efficacy and domain interest items, were neutral or agreed to the connection to instructor items, and agreed or strongly agreed to the instructor passion items. In terms of transformative experience, a mean Rasch score of 1.91 indicates that, on average, the learning was quite transformative. Students were likely to endorse all but the highest transformative engagement items. All the predictor variables were significantly positively correlated with transformative experience. These correlations ranged from moderate (self-efficacy) to large (interest, connection to instructor).

Table 1. Descriptive Statistics and Correlations.

Variable.	*N*	*M*	*SD*	Correlations			
				1	**2**	**3**	**4**
Predictors							
1. Self-Efficacy (pre)	340	4.07 [1]	0.68	–			
2. Domain Interest (pre)	340	3.72 [1]	0.91	0.49 **	–		
3. Connection to Instructor (post)	340	3.27 [1]	1.11	0.19 **	0.57 **	–	
4. Instructor Passion (post)	343	4.22 [1]	0.85	0.13 *	0.27 **	0.57 **	–
Outcome Variable							
5. Transformative Experience (post)	341	1.59 [2]	2.83	0.28 **	0.70**	0.66 **	0.45 **

Note: [1] Responses were on a 5-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). [2] Measured in logits; ≤ -2 = Not at all transformative, ≥ 2 = Highly transformative. * $p < 0.05$. ** $p < 0.01$. Based on Cohen's [69] general rules of thumb for interpreting correlations, small = 0.1, moderate = 0.3, and large = 0.5.

To further explore the relation between variables, we centered the predictor variables and conducted a hierarchical multiple regression (see Table 2). In step one, we entered the control variables, self-efficacy, and domain interest. As expected, these variables explained a large amount of variance in transformative experience scores, $R^2 = 0.50$, $F(2, 334) = 164.97$, $p < 0.00$, with domain interest being a large ($\beta = 0.75$) and statistically significant predictor. Surprisingly, self-efficacy was a weak but statistically significant *negative* predictor. However, the predictive relationship was weak and self-efficacy and transformative experience were significantly, positively correlated on their own. Multicollinearity is a consideration as self-efficacy and domain interest were strongly correlated. However, the collinearity statistics (Tolerance = 0.75, VIF = 1.3) were well within the conservative guidelines of Tolerance > 0.25 and VIF < 4.

In step two, we entered the connection to instructor and instructor passion variables. Together they provided a statistically significant increase in the amount of variance explained, $\Delta R^2 = 0.11$, $F(3, 331) = 32.41$, $p < 0.00$. In practical terms, these variables together accounted for an additional 11% of the variance explained, with 61% of the variance being explained by the full model. In line with our hypotheses, both connection to instructor and

instructor passion were statistically significant predictors, even controlling for students' initial interest and self-efficacy in the domain. Connection to instructor was the stronger predictor of the two. The interaction between connection to instructor and instructor passion was not a statistically significant predictor of transformative experience.

Table 2. Predicting Transformative Experience.

Predictor	B	*SE* B	β	R^2
Step 1				
Self-Efficacy	−0.38	0.19	−0.09 *	0.50 **
Domain Interest	2.31	0.14	0.75 **	
Step 2				
Self-Efficacy	−0.24	0.17	−0.06	
Domain Interest	1.61	0.15	0.52 **	0.61 **
Connection to Instructor	0.73	0.13	0.29 **	
Instructor Passion	0.58	0.17	0.18 **	
Conn. to Inst. * Inst. Passion1	0.08	0.10	0.04	

Note: $N = 343$. [1] Interaction between Connection to Instructor and Instructor Passion. * $p < 0.05$. ** $p < 0.01$. For R^2, statistically significant changes between steps are noted.

4. Discussion

In line with expectations and prior research [14,17], students' interest in the domain was a strong base-line predictor of higher levels of transformative experience. This finding supports the contention by Pugh et al. [35] that transformative experience represents a particular manifestation of interest. That is, one way in which students might demonstrate an interest in a domain such as geoscience is by engaging with the content outside of school and using to see the world in a meaningful, new way.

Also in line with expectations, student' sense of connection to instructor(s) was an important predictor of transformative experience, even controlling for initial domain interest and self-efficacy. This finding aligns with prior research finding that the quality of student–faculty relationships is predictive of related engagement outcomes such as motivation, effort, and academic and career choice [42,48]. Questions remain about the mechanism by which a sense of connection to instructor(s) relates to undergoing transformative experiences. Hagenauer and Volet [42] theorize that student–faculty relationships influence student engagement by increasing students' sense of belonging. Likewise, self-determination theory and engagement theory propose that positive student–teacher relationships facilitate intrinsic motivation and engagement by satisfying the need for relatedness [70–72]. Future research is needed to investigate whether the relation between students' sense of connection to their instructor(s) and undergoing transformative experiences is mediated by their sense of belonging.

As hypothesized, perceived instructor passion was also a statistically significant predictor of transformative experience, even controlling for domain interest and self-efficacy. The connection between perceptions of instructor passion for the content and transformative experience may be explained through the idea of emotional contagion [52]; that is, teachers' emotions have been found to carry over to the students [53,54]. Thus, passion for content may be passed from the instructor to the students, facilitating transformative experiences. In the current study, we measured students' perception of their instructors' passion for the content. Individual perceptions may vary, and the results of the current study suggest perceiving instructors as more passionate about the content is associated with a higher level of transformative experience. Future research could tease out perceptions from objective teacher expressions.

Contrary to our expectations, the interaction between perceived connection to instructor and instructor passion was not a statistically significant predictor of transformative experience. Based on findings that models tend to be more influential when they are relatable [55,56], we hypothesized an interaction between perceived connection to instructor and instructor passion. That is, instructors' expressions of passion for the content may be

more influential when students perceived a connection to the instructor(s). This hypothesis was not confirmed by the data suggesting perceived connection to instructor and perceived instructor passion are independent factors. However, in the current study, student perceptions of connection and passion were not necessarily linked to the same instructor. On the survey, students were asked to indicate the level of connection to their geoscience "instructor(s)" and the perceived level of passion they observed in their geoscience "instructor(s)." Thus, students enrolled in a single geoscience course likely referenced a single instructor, whereas students enrolled in multiple geoscience courses likely referenced their "average" perception across geoscience instructors. Future research is needed to either confirm the results from the current study or explore the potential interaction between connection to instructor and instructor passion in more depth.

Finally, even though self-efficacy was only included as a control factor in the current study, it is worth noting the surprising finding that it was a significant negative predictor of transformative experience. This finding contrasts with prior research finding self-efficacy to be a positive predictor of engagement [73,74]. However, the predictive relationship was weak and we recommend future research.

4.1. Implications

The results of the current study confirm perceived connection to instructor and perceived instructor passion are important factors related to students undergoing transformative experiences in science. Thus, science teachers may be able to facilitate transformative experiences by connecting with students and sharing their passion for the content. Prior research yields insights into how science teachers could do this. Teachers can foster a sense of connection by providing individual attention and expressing explicit concern for the well-being of the student [75–77], engaging in casual conversation with students before and after class [78], focusing on student growth as opposed to just performance on a particular educational task [79], portraying themselves as partners in the learning process rather than lecturers whose primary goal is to deliver information [80,81], validating student questions, ideas, and identities [82,83], and displaying approachable non-verbal behavior (e.g., smiling, leaning forward, making eye contact) [84]. Science teachers can express passion for the content by sharing personally meaningful stories of science [85] and their own transformative experiences with the content [86]. Administrators can support the development of instructor passion by creating an autonomy-supportive environment [87,88].

4.2. Limitations

The current study investigated the relation between transformative experience and the student–teacher dynamic in a university setting and the results may not generalize to other contexts. The relationship between science teachers and students changes dramatically over grade levels and, hence, the importance of this relationship to transformative experiences may vary. Additional research is needed to explore the relation between students' sense of connection to their science teachers and transformative experience in primary and secondary contexts.

Additionally, the current study is correlational and does not provide causal evidence for the influence of the teacher–student dynamic on transformative experience. Intervention studies are needed to establish causal relations. Further, it is possible the relations identified in the current study are reciprocal. That is, an increased sense of connection and perception of passion likely fosters transformative experiences. On the other hand, transformative experiences may contribute to perceptions of a connection with science teachers and may influence perceptions of their teachers' passion for the content. Future research could explore the reciprocal nature of this relationship.

5. Conclusions

As expressed by Feinstein [89], the purpose of science education is not just to acquire knowledge and skill, but to enrich students' everyday experiences in the world. Simply

put, science education should make life more interesting and meaningful. The construct of transformative experiences provides one representation of this outcome. The current research suggests science students' sense of connection to their instructor(s) and perception of their instructors' passion for the content are related to their transformative experiences. Science instructors may be able to foster transformative experiences by developing meaningful relationships with students and expressing their passion for the content. However, experimental research is needed to establish a causal relationship.

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